

Fire at the Urban Wildland Interface:

Cost-Benefit Evaluation of Proposed California State Fire Marshal Building Construction Regulations

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IFB #5CA334189
FCA #05-6369
Reporting Date: 7-28-04

Cover photo: Southern California fire of fall 2003. Courtesy Rolland Crawford.

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Executive Summary

The State of California has a significant economic interest in reducing annually recurrent losses from fires in the urban wildland interface [UWI] areas within the state.¹ Costs to the state in recent years have markedly affected both the private and public sectors ranging in excess of \$2 billion for replacement of personal property and hundreds of millions of dollars in suppression costs.

As the UWI fire problem has grown in importance, attention of government to the problem has grown as well. After a series of UWI wildfires in the early 1990s, initiatives were developed by the State of California to enhance state regulatory authority and related codes addressing development in UWI areas; these have resulted in the writing of a new UWI code. The goal of that program has been reducing the vulnerability and increasing the survivability of new homes to attack by recurrent wildfires.

Most recently, the Office of the California State Fire Marshal has developed a series of proposed UWI building standards. These call for inclusion of a new set of caveats, as well as five new UWI building test standards in Chapter 7 of the California Building Code. The costs and benefits associated with implementation of the proposed regulations are important features that will impact their proposed adoption. The study presented here was conducted by Fire Cause Analysis of Point Richmond, California, in response to a request for proposal from the Fire Marshal's office². The study has included a comprehensive review of specific data collected under the auspices of the State Fire Marshal Office after the major wildfires in Southern California in late 2003.

In this report, economic and construction data was evaluated to estimate impact on various business sectors and specific costs associated with the proposed regulations if implemented. In preparing this report, a specific data set generated in the after-action analysis of these fires was complemented by general and historical information concerning UWI fire safety issues and the results of fire safety engineering and research activities, primarily conducted by the University of California Forest Products Laboratory, to provide sound technical evaluations and descriptions of the fire performance of common construction assemblies elements and technology used in buildings found in UWI areas.

Complementing this technical data, economic and construction cost data was collected, which ranged from dollar volumes involved in residential construction in California and in UWI areas of California, down to costs of specific construction elements involved in the proposed regulations such as window glazing, doors, venting, wall constructions, roof assemblies and appurtenances such as combustible decks and patios. The study found that of seven construction-related areas, such as those listed above, the projected regulations might cause a minor increase in four areas such as decked construction, gutters used, and attic venting in conjunction with roof and heat installations.

¹ UWI areas are locations characterized as having been wildland in the past 50 to 100 years and were subsequently developed, sometimes intensively, for housing, usually in the form of single-family dwellings. Often vegetation reminiscent of the original wildland area remains in UWI. This vegetation, in conjunction with topography, local ecology and development patterns, has created a serious and growing fire problem.

² Fire Cause Analysis is a multidisciplinary fire safety engineering and investigation firm formed in the late 1970s. Its work areas include research and development for public and private sector clients, investigation in forensic evaluation of fire losses and fire safety questions, and consulting in litigations associated with fire investigation and fire safety questions.

Based on estimates made by a licensed contractor-cost estimator, factored with industrial information, available data indicates that for a typical 1750 square-foot ranch house, the increase in construction costs would average \$1525 for each home built before application of developer markups. With a 40% developer markup applied, this total figure comes to \$2135, which amortized over 30 years results in an increase of \$71.17 per year of home cost, or an increase of \$0.04 per square-foot for the baseline home size of 1750 square feet. Analyzing this increase on the basis of percentage of increase in per home costs, the projected increase are less than or in the range of 1%, depending on practices related to application of developer markups.

For comparison purposes, evaluation of single-family dwelling costs and permits issued, estimating that 10% of these relate to UWI housing construction, suggests that values of housing built are increasing at \$250 to \$300 million per year. Thus, the estimated cost of the projected regulations of under \$30 million per year is an order of magnitude smaller than annual construction cost increases. Conversely, if the regulations are not enacted, and their impact on the survivability of the UWI housing stock is allowed to accrue, we can anticipate continuation of losses of private-sector property in the multibillion-dollar range and suppression costs to the state on the order of hundreds of millions of dollars per year. Giving the proposed standards regulatory status will provide clarity and a lack of ambiguity, consistent with the needs spelled out in the recommendations of Governor Schwarzenegger's task force, which reviewed the impacts of the most recent spate of wildfires³.

Adoption and application of the standards should be considered one component of a broader mitigation strategy. That strategy should include enhanced planning activities prior to development, evolution of fuel management techniques and application of new methods to encourage development and maintenance of defensible space through initiatives both by local authorities having jurisdiction (AHJ) and insurance carriers to ensure that buildings constructed in UWI areas are sited and maintained properly.

³ "Report to the Governor", Blue Ribbon Fire Commission, April 4, 2004.

1. Introduction

In terms of both extent and value of damage caused, the October 2003 wildfires in Southern California were unprecedented. Their effects on the lives of California's citizens, as well as the economic impact they created within the state, cannot be underestimated.⁴

As noted in the "Report to the Governor", the effects of these fires extended beyond affected property owners and local communities. From a tactical perspective, massive efforts - with accompanying allocations of scarce state funds - were required to suppress these fires.

From a strategic perspective, the after-action reports on these fires highlight areas in which long-term mitigation efforts can be made to prevent frequent repetitions of these incidents. Consideration of mitigation strategies is particularly relevant, because the specific locations where the fires of 2003 occurred were quite varied and not unique or singular as compared to other developed Urban Wildland Interface [UWI] areas in California. Moreover, as the 2004 wildfire season develops, it is apparent that the fires of 2003 have put the State of California on notice that, in the absence of serious mitigation efforts, fires on this scale will become the rule rather than the exception in future years. Specifically, the most recent fires involved \$2.04 billion in property losses for the 1.9 million property claims filed and suppression costs in the range of \$250 million.

Factors which figured prominently in the levels of damage from these fires included the following:

- Impact of combustible vegetation
- Impact of inadequate defensible space around affected buildings
- Impact of construction materials and practices
- Impact of wind driven aspect of the fires

As can be inferred from this list, the first three of these factors can be addressed through mitigation efforts. Consistent with that observation, the Governor's Blue Ribbon Fire Commission Report included recommendations that addressed those hazards.

Before the 2003 fires ignition resistance and other fire performance aspects of building construction have been the subject of state sponsored research. For example, subsequent to the firestorms of 1993, research to address construction issues was initiated under funding from the California Legislature through AB 1216. At the same time, active work was begun to develop a UWI building code document. A review of the results of that research in conjunction with observations from the after-action reports of the 2003 fires make a powerful case for putting in place specific *minimum construction standards* for *very high fire severity zones*.

Hazards intensified to date in the fire performance of current construction practices in such areas demonstrate that a specific set of needs exist which can be *readily and cost effectively* addressed to reduce foreseeable expenditures for building replacement and fire fighting. While these priorities will remain important during the coming years, given the increasing high degree of fire

⁴ The recently published "Report to the Governor" (Blue Ribbon Fire Commission, April 4, 2004) provides a dramatic review of the extent of the impact of this catastrophe on our State.

risk demonstrated in UWI locations in California – and other US areas with similar characteristics - such changes in construction practices are needed.

The Office of the State Fire Marshal in California has been supporting research in building and fire issues for some years.⁵ Results of this work have helped in the development of a blueprint for the future by providing the means to mitigate the threat posed by UWI fires. One such current program is the “Technical Study for Code Development”,⁶ created to evaluate science and technology associated with the fire performance of buildings and constructions involved in UWI fires to date and to meaningfully apply the results of those evaluations to new regulatory efforts. As part of that program, contemporary guidelines and requirements for future construction in areas at risk from UWI fires have been developed.

The objective of this report is to provide information on potential costs associated with enactment of the proposed construction regulations to various segments of the California economy. The report also includes data addressing the costs to California *not regulate construction* using currently available minimum standards technology. As a consequence of this strategy, potential costs to *not mitigate* would be shifted from development and construction related segments of the private sector to the insurance industry that replaces fire-damaged properties and to the government sector that funds the ever-increasing fire suppression costs.

⁵ Summary data on fire Mitigation supported in part by the State of California can be found at <http://nature.berkeley.edu/~fbeall/firemit.html>

⁶ These are addressed in IFB number 5CA334189 which has provided support for this study and report.

2. Economic Impacts of the Proposed UWI Building Regulations

When new regulations are proposed, it is important to consider the potential economic impact. In this section the potential economic impacts are identified and addressed using the best economic information available. A subsequent section will comment on the potential costs of not addressing the problem.

2.1 Businesses, Jobs & Dollar Volume Potentially Affected

Businesses potentially affected by the proposed building code regulations include virtually every segment of the construction industry currently involved with development and construction in UWI areas. The table below provides a measure of direct and indirect employment associated with residential construction in California. An associated appendix [Appendix I] lists the 48 indirect categories for which data is available and includes categories such as wholesale trade, food related businesses, architectural and engineering service, employment services, retailers, health services, building materials suppliers, transportation, kitchen cabinet and countertop manufacturing and many others.

From data in the table below [and from the table in Appendix I] it can also be concluded that single family residential construction accounted for 81.4% of direct employment in that sector in 2003 or 194,916 jobs from a total of 239,440.

Table 1: California Employment in New Housing Construction

Summary of Economic Benefits from New Residential Construction in California	Direct Component	Indirect Expenditures	Induced Expenditures	Total of All Sources
2001 Number of Employees	183,893	111,273	108,428	403,594
2002 Number of Employees	207,106	126,905	122,569	456,579
2003 Number of Employees	239,440	145,251	141,285	525,976
Computed Using the Minnesota IMPLAN model, 2001 coefficients. Data Source: US Census Bureau. SACTO-CSUS Sacramento Regional Research Institute, February 2004.				

A number of different bases can be used to estimate measures of population/numbers of households associated with the UWI areas as compared to total population/numbers of households within the State of California. One approach is that followed by the Spatial Analysis for Conservation and Sustainability Lab (SILVIS). Working with the University of Wisconsin at Madison and the USDA Forest Service, SILVIS has developed a population model based on housing density. They believe that housing density of an area ‘can be a more suitable measure of human presence and influence on the landscape than population density’.⁷ Utilizing numbers developed using SILVIS data nationally, 18.8 % of homes and 10% of land area exist in UWI areas. For California, estimates are that 5.1 million homes have been built in UWI areas, accounting for 41.75% of housing units in the state. The latter figure, however, appears to be quite high.

⁷ “Characteristics and Location of the Wildland-Urban Interface in the United States”; Susan Stewart, Volker Radeloff, and Roger Hammer; 2000.

USDA Forest Service analyses have spawned a second methodology to estimate UWI populations. The basis for their definition of interface regions uses population density rather than housing density.⁸ They define the UWI as regions with 40-400 people per square mile, and have derived their data from LandScan 2000, an international population data set prepared by Oak Ridge National Laboratory for the Department of Defense. Results of that analysis suggest that 4.36% of the population in California lives in UWI areas.

Application of the data developed using these two methodologies suggest a range of UWI populations from 4.5% to 18% with a median value of 11%. As such, it can reasonably be argued that approximately 21,500 (with a range from 35,000 to 8,750) construction jobs are directly involved with activities on UWI projects and that similar numbers of construction industry dollars are spent in this sector.

For comparison purposes, economic benefits related to all residential construction in California in dollars over the past three years are summarized in the table below:

Table 2: Total Industry Output of New Housing Construction Industry (Billions of Dollars)

Summary of Economic Benefits from New Residential Construction in California	Direct Component	Indirect Expenditures	Induced Expenditures	Total of all Sources
2001 Total Industry Output	\$23.65	\$10.99	\$10.86	\$45.50
2002 Total Industry Output	\$26.86	\$12.53	\$12.28	\$51.67
2003 Total Industry Output	\$30.85	\$14.35	\$14.15	\$59.35
Computed Using the Minnesota IMPLAN model, 2001 coefficients. Data Source: US Census Bureau. SACTO-CSUS Sacramento Regional Research Institute, February 2004.				

Applying the same range of values as were used to estimate numbers of jobs associated with construction in UWI related projects, it can be calculated that direct activities related to UWI projects generated a median value of \$ 3.39 billion dollars in 2003. The table that follows shows the range of the expenditures – both direct and indirect based on conservative and expansive assumptions respectively.

Table 3: Estimates of Expenditures Associated with UWI Projects - 2003

Estimate	Direct Expenditures*	Indirect Expenditures*	Total Expenditures*
Maximum	5.53	2.58	8.11
Mid Level	3.39	1.58	4.97
Minimum	1.39	0.65	2.04
*Billions of dollars- Based on 2003 California total of \$30.85 billion direct expenditure and \$14.35 billion indirect expenditures			

Indirect benefits are defined as additional economic activity created in association with residential construction in UWI areas. Examples of such activities include “wholesale trade, building supplies where builders purchase lumber, roofing, electrical, plumbing and other components, motor freight, management and construction and consulting services,

⁸ “Using GIS to identify potential wildland-urban interface areas based on population density”; Matt Kamp & Neil Sampson, USDA Forest Service.

engineering and architectural services, who participate in the design and planning of housing.”

Other relevant information which details construction-related activity in California UWI areas are as follows:

Annual housing production for 2003 statewide was estimated at 188,000 units, contributing \$59 billion for the year while generating nearly 526,000 jobs. This sector accounted for nearly 2% of the California economy.⁹ These numbers are of the same order of magnitude as those derived above. Expenditures made by homebuilders and employees who work for builders in 2003 created direct benefits of \$31 billion. This is an increase from \$24 billion in 2002 and \$27 billion in 2001.

McGraw-Hill Construction - California Construction Link reported [July 1, 2004] on a CBIA forecast that homebuilding is expected to remain steady for the next 18 months. In areas directly related to the 2003 Southern California wildfires, Riverside and San Bernardino counties have represented the largest new housing market in California in the past 10 years and have also been the fastest-growing. According to NAHB comments, in 1995 approximately 10,000 building permits were issued in these areas, which can be compared to 2002, when the market grew to 33,280 permits. Due to the availability of open land, in 2003 the housing market grew 8.2% to 36,000 permits. This has helped propel San Bernardino and Riverside Counties’ “Inland empire” area - scene of much of the property lost in fall 2003- into its position as a front-runner from a growth perspective.

⁹ “The Economic Benefits of Housing in California,” March, 2004. Prepared by the Sacramento Regional Research Institute, 400 Capitol Mall, Suite 2500, Sacramento, CA 95814.

2.2 Impact of the Proposed Regulations on Construction Practices

The impact of the proposed new regulations will not be major for the contractors and sub-contractors actually putting buildings together. Results show that builders and developers *will* be required to work somewhat differently than in the past in terms of how buildings are put together and what materials they use. However, adoption of the proposed requirements will not involve particularly different or radically new construction techniques. Rather, to reduce the threat of building ignition, revisions will involve either:

- a. Application of revised construction techniques to eliminate *fire intrusion into dwellings* based on foreseeable fire occurrence, or
- b. Utilization of revised designs *incorporating occasionally different but readily available materials or assemblies*.

Architects and engineering personnel will also be asked to provide different and possibly more precise guidance on building practices than in the past. These changes in the proposed regulations are not expected to materially influence the time spent on the design and engineering of given structures once the professionals involved become acquainted with the new requirements.

Broader questions still remain as to the costs associated with fire mitigation for the developers who build in UWI areas. These businesses may, as part of their own due diligence planning efforts *increase* their efforts to recognize emerging approaches for any new developments as well as the spacing between buildings. *However, any increases in development costs associated with these revisions to construction planning and development are unrelated to the proposed standards.*

Likewise, access to developments, susceptibility to terrain driven wildfires, and possible addition of features such as flame deflection walls may require reconsideration as part of overall planning efforts. However, as with the previous comment, the proposed construction regulations themselves *should not be expected to lead to increases in development costs.*

2.2.1. Economic impact to builders and developers: Ranges of comparative costs - compliant and non-compliant systems

The UWI Building Standards being proposed for Chapter 7A of the **California Building Code** (CBC) include methodologies embodied in five standards with commentary. The fire test standards proposed are as follows:

- SFM-1: Exterior Walls, Siding and Sheathing.
- SFM-2: Exterior Windows
- SFM-3: Eaves
- SFM-4: Roof Assemblies.
- SFM-5: Decks and Other Horizontal Ancillary Structures

Each of these standards provides a methodology and a detailed commentary relating to the problem, so that a reasonable evaluation of the fire performance of a given construction assembly can be conducted and those results compared to the proposed minimum standard.¹⁰

The underlying research that led to development of the standards resulted in a database that allows for comparison between assemblies that comply with the proposed minimum and those that would be rated as substandard according to the proposed regulations.

To test whether compliant assemblies are consistently more expensive than existing assemblies, a series of discussions are presented in this section, so that current in-place costs, including materials and labor costs, of compliant versus noncompliant systems can be compared.

2.2.1.1. Construction Estimating Procedures¹¹

The construction estimates were developed using vendor sources for materials costs and in-field experience for installation rates. In addition, R.S. Means Construction Cost Data was referenced and subcontractors consulted as needed for selected items. The costs presented are for average rates in the Sacramento area in 2004.

The specific cost estimates created, which include both materials and labor costs, are as follows:

1. Wall coverings and claddings
2. Roofing
3. Exterior deck surfaces
4. Window installations
5. Roof, eave installations

¹⁰ Copies of the current draft standards are appended in appendix II.

¹¹ Carter-Gough & Company of Martinez, Ca. prepared the estimates included in this report. Their work areas include activities as a construction consulting firm and Carter-Gough Construction, Inc., a licensed general contracting company.

6. Venting
7. Gutter materials

The cost data developed in these estimates is discussed in the following sections.

2.2.1.1.1. Wall coverings and claddings

Claddings and wall coverings were evaluated on a per-square-foot basis utilizing four possible underlayments or sheathing materials/approaches.

Research conducted with building products suggest that the nature of sheathing materials is correlated to the success of an exterior wall during fire exposure if the exterior cladding material is combustible. Secondly, it has been identified that the fire performance of joints in cladding materials represents an important feature.

Gypsum sheathing tends to be the most fire-resistant material, with wood-based sheathing materials of different sorts [plywood, OSB board] providing satisfactory performance under some but not all combustible cladding materials. Other underlayment materials such as polystyrene backer board or simple building paper provide little if any value in terms of fire resistance.

As a point of reference, the following table from the 2000 U.S. Census provides current national data on cladding materials used in single-family dwellings:

In the present case, cost estimates, with gypsum, plywood, OSB and simple building paper were prepared with claddings including T-111 siding, shiplap and beveled wood siding, three-coat stucco, vinyl siding, fiber cement siding and board and batten siding based on lumber.

For systems utilizing **gypsum sheathing** the following, installed costs on a square foot basis were developed by siding type:

T-111 Plywood (5/8")	\$4.01
Cedar wood siding	\$6.37
Three-coat stucco with color	\$6.56
Hardboard siding with paint	\$3.98
Vinyl siding	\$3.28
Fiber cement siding with paint	\$4.23

For **plywood sheathing** the following installed costs per square foot were developed by siding type:

T-111 Plywood (5/8")	\$4.74
Cedar wood siding	\$7.10
Three-coat stucco with color	\$7.29
Hardboard siding with paint	\$4.71
Vinyl siding	\$4.01
Fiber cement siding with paint	\$4.96

For **OSB sheathing** the following installed costs per square foot were developed by siding type:

T-111 Plywood (5/8")	\$4.63
Cedar wood siding	\$6.99
Three-coat stucco with color	\$7.18
Hardboard siding with paint	\$4.60
Vinyl siding	\$4.40
Fiber cement siding with paint	\$4.85

As can be seen from these figures, the installed cost of common siding options that include the most fire-resistant sheathing and that have the highest likelihood of success overall are no more costly than installations using the same cladding materials applied over less fire-resistant sheathing.

A complete listing of the combinations evaluated can be found in Appendix III. These include factors used in the computations for labor, materials and associated installations of each set of components.

While issue may be taken with some of the combinations of materials found in these cost estimates [as examples, vinyl siding is rarely if ever installed over gypsum sheathing, and multiple layers of plywood sheathing and siding are rarely used], the variations and ranges in costs determined clearly show little if any premium for in-place siding system costs that meet the proposed standard.

Principal Type of Exterior Wall Material of New One-Family Houses Completed

(Components may not add to totals because of rounding. Percents computed from unrounded figures.)

Year	Number of houses (in thousands)							Percent distribution						
	Total	Brick	Wood	Stucco	Vinyl siding	Aluminum siding	Other ¹	Total	Brick	Wood	Stucco	Vinyl siding	Aluminum siding	Other ¹
West														
1973	253	15	87	115	(NA)	(S)	35	100	6	34	45	(NA)	(S)	14
1974	191	14	76	76	(NA)	3	23	100	7	40	40	(NA)	2	12
1975	182	15	75	73	(NA)	3	16	100	8	41	40	(NA)	2	9
1976	232	14	100	103	(NA)	4	11	100	6	43	44	(NA)	2	5
1977	311	21	134	135	(NA)	4	16	100	7	43	44	(NA)	1	5
1978	357	23	160	146	(NA)	6	22	100	6	45	41	(NA)	2	6
1979	337	19	158	131	(NA)	7	22	100	6	47	39	(NA)	2	7
1980	233	14	107	92	(NA)	6	14	100	6	46	40	(NA)	3	6
1981	183	12	86	69	(NA)	6	10	100	6	47	37	(NA)	3	6
1982	121	12	60	39	(NA)	3	7	100	10	49	32	(NA)	2	6
1983	200	13	96	74	(NA)	8	10	100	6	48	37	(NA)	4	5
1984	233	8	101	104	(NA)	7	12	100	3	43	45	(NA)	3	5
1985	239	6	103	110	(NA)	10	11	100	3	43	46	(NA)	4	4
1986	253	6	108	120	(NA)	10	8	100	3	43	48	(NA)	4	3
1987	259	6	103	133	(NA)	9	8	100	2	40	52	(NA)	3	3
1988	248	6	100	132	(NA)	5	6	100	2	40	53	(NA)	2	2
1989	257	6	92	149	(NA)	5	5	100	2	36	58	(NA)	2	2
1990	255	6	105	132	(NA)	5	6	100	2	41	52	(NA)	2	2
1991	205	5	91	96	(NA)	7	6	100	3	44	47	(NA)	3	3
1992	232	9	99	107	3	10	4	100	4	43	46	1	4	2
1993	247	8	112	109	6	10	3	100	3	45	44	2	4	1
1994	285	10	120	131	10	9	5	100	4	42	46	3	3	2
1995	253	6	98	126	13	4	6	100	2	39	50	5	2	2
1996	269	8	96	140	16	4	5	100	3	36	52	6	2	2
1997	259	6	84	140	20	(S)	8	100	2	32	54	8	(S)	3
1998	283	5	83	154	27	(S)	11	100	2	29	55	10	(S)	4
1999	310	5	78	171	37	3	17	100	2	25	55	12	1	5
2000	286	4	66	160	40	2	15	100	1	23	56	14	1	5
2001	303	4	59	178	33	1	27	100	1	20	59	11	(Z)	9
2002	325	3	55	199	35	1	32	100	1	17	61	11	(Z)	10
2003	363	5	42	230	40	2	44	100	1	12	63	11	(Z)	12
RSE	2	37	23	9	25	32	23	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)	(NA)

- Represents zero. A Represents an RSE that is greater than or equal to 100 or could not be computed

NA Not available. RSE Relative Standard Error.

S Withheld because estimate did not meet publication standards on the basis of response rate, associated standard error, or a consistency review

Z Less than 500 units or less than 0.5 percent

¹Includes cinder block, stone, fiber cement, and other types. Data prior to 1992 include vinyl siding.

Note: Single-family estimates prior to 1999 include an upward adjustment of 3.3 percent made to account for structures built in permit-issuing areas without permit authorization

2.2.1.1.2. Roofing Systems

Cost estimates were developed for a variety of roofing materials including appropriate roofing felt underlayment and associated installation labor. Sheathing materials were included where necessary to achieve Class A assembly fire rating.

Systems evaluated included composition shingles [Class “A” and Class “C”] concrete tile, and fire retardant treated wood shingles. The Class “C” composition shingle roof was included for comparison purposes, since it would not be expected to meet the proposed regulations. Such Class C compliant materials are not currently permitted in canyon and brush land areas.

For each roofing material type, the following installed costs per square foot were developed by roof assembly type:

Class A comp. shingle	\$1.42
Concrete tile	\$3.79
Class A Wood Shingles including Gypsum Sheathing	\$5.56
Class C comp. shingle	\$1.14
Built up roofing 4 ply system w/ T&G, overlay, flashings	\$2.37

Appendix III includes the cost data on which the roofing estimates referred to here are based.

The cost impact of the proposed roofing regulations appears to be minimal and consistent with current good practice inasmuch as surveys in home centers and of roofers show that few such distributors carry Class C or B composition shingles [the lowest priced option], since Class A analogs are only slightly more expensive and last longer, providing greater value.

For comparison purposes, the estimated values described above may be compared with Attachment #4 of the after-action report of the San Diego City Managers, published after the 2003 fires. That report shows that for a 3000 square-foot house, the difference between an asphalt shingle roof and a lightweight concrete tile roof is approximately \$8,500, depending on material quality and installation.

Interestingly, if the Class A options provided above are evaluated for 3500 square feet of roofed area, the difference between the Class A composition shingles and the cement tile roof totals \$8,395, which is remarkably close to the \$8,500 difference cited in the previous paragraph. Both are more expensive than the poorer performing Class C composition shingle cited above.

All other costs quoted in the San Diego City Managers report are for re-roofing as opposed to roof installations for new construction.¹²

¹² City of San Diego City Managers Report, 1-14-2004. Report No. 04-005 by P. Lamont Ewell, Assistant City Manager - vertical enclosures.

2.2.1.1.3. Exterior deck surfaces

The proposed regulations include provisions for testing deck constructions to determine resistance to ignition from fires both above and below deck surfaces.

Testing of those materials has been conducted, and certain types of both wood and plastic decking will meet the proposed standard with necessary construction detailing. An additional deck alternative is the membrane walking deck, a highly economical plywood-walking deck, with urethane resin surfaces. It is anticipated that a version of this system will meet the proposed standards.

For the decking material types evaluated, the following installed costs per square foot were developed by decking type¹³:

Clear Heart Redwood decking	\$18.94
Trex plastic decking	\$ 7.23
Membrane walking deck – urethane over plywood	\$ 2.99

These square foot costs do not reflect the differences due to additional costs for detailing of patio and deck assemblies to meet the proposed standards and regulations. This detailing, such as a deck skirt or a stucco surround, will prevent the entry of burning embers into the area below the deck. Costs to add skirting can be expected to increase deck and patio expenditures by up to 10%.

2.2.1.1.4. Window installations and costs

Window costs can be anticipated to remain unchanged following adoption of the proposed regulations. This is because, at present, virtually no single glazed alternatives exist which meet requirements of the current **California Energy Code**. For this reason, virtually all new construction is built with double or triple glazing which also provides enhanced fire performance.

Window costs developed in this study for 3’ by 4’ windows include \$363.73 for an aluminum double glazed version, \$ 296.95 for a vinyl double glazed version and \$ 601.93 for a wood frame double glazed version.

Because vinyl windows are popular and cost effective and because issues have been raised as to the ability of vinyl frames to remain in place, research was conducted into the availability of vinyl windows systems meeting the proposed requirements. Based on correspondence available from authorities having jurisdiction in Southern California, issues of fire performance of vinyl windows have been addressed and

¹³ See appendix III for installed decking costs on a per square foot basis.

vinyl window alternatives are routinely available that will meet the proposed standards.¹⁴

2.2.1.1.5. Roof, eave installations

The proposed regulations would require either closed eave designs or unspecified performance-based modifications for continued use of open eave designs. As such, comparisons were prepared for various eave designs on linear foot bases.

Eave systems evaluated per linear foot resulted in the following cost estimates:

Wood Eave with open Soffitt including blocking, screened 2” holes for ventilation with paint.	\$ 15.28
Wood Eave with enclosed Soffitt including blocking, screened 2” holes for ventilation with paint.	\$ 19.37
Wood-framed eave with enclosed, stucco-covered Soffitt incl. blocking, screened 2” holes for ventilation with paint.	\$ 33.26

From these costs it is apparent that there will be an increase in cost for soffit closures on the order of 25% for wood construction. Costs in excess of this 25% premium to provide closures of soffits on stucco-finished buildings can also be anticipated.

Issues with regard to soffit configurations and *necessary* associated venting are essentially in flux, therefore it can be anticipated that changes in available designs and assemblies will occur. Eventful revision of this important design feature will be driven in part by the ongoing need to have adequate ventilation in all attics of all buildings including those in UWI areas.¹⁵ As such, suggestions to close soffits completely while advantageous for fire safety will result in potentially damaging conditions in attics unless alternatives to current venting approaches are utilized. Conventional approaches such as use of properly screened eyebrow and ridge vents may work in the short term, although alternatives such as large gables and vents sometimes coupled to turbine ventilators should be avoided in UWI areas.

2.2.1.1.6. Venting

Maintenance of appropriate attic ventilation remains an important issue. For that reason, installed cost estimates were developed for roof eyebrow vents and roofing ridge vents along with the more conventional soffit venting. The former are rectangular vents having an area of approximately 0.5 square feet, which are capable

¹⁴ See Appendix IV – Letter of 8-24-2001 from Ranch Santa Fe Fire Department and SD City Personnel to Advanced Window Technology of San Diego, Ca.

¹⁵ See CBC Section 1505 [“Attics: Access, Draft Stops and Ventilation”] for relevant information. These requirements call for vent areas which are in a range of 1:150 of net attic floor areas.

of venting up to 75 square feet of attic floor area per vent. The cost per vent installed is \$66.90.

For roof ridge vents, which are continuous vent strips, the installation costs are \$4.88 per square foot. Such venting has a vent area of 96 square inches per linear foot (0.67 sq ft.), rendering these vents capable of ventilating up to 100 square feet of attic space per linear foot of vents installed.

2.2.1.1.7. Gutter Materials

The proposed regulations will prescriptively prohibit use of gutters based on combustible materials such as wood or PVC.

Installed costs associated with the common options for gutters follows:

Aluminum	\$5.11 per linear foot
Vinyl	\$4.86 per linear foot
Galvanized Steel	\$5.17 per linear foot

The numbers above suggest that the regulations proposed will generate a modest increase in gutter costs. If vinyl gutters had previously been the material of choice, use of acceptable alternatives would result in cost increases in the range of 5-6%.

2.2.2. Costs of the proposed UWI Building regulations

The preceding section presented cost estimates for changes in construction details and assemblies associated with the proposed regulations. Seven construction assemblies or systems potentially subject to regulation under the proposed rules were evaluated. Results are summarized as follows:

1. Wall coverings and claddings – no change in current costs/current material choices.
2. Roofing – no change in current costs/current material choices.
3. Exterior deck surfaces - changes may occur as compared to current costs
4. Window installations – no change in current costs/current material choices.
5. Roof, eave installations – changes may occur as compared to current costs
6. Venting - changes will occur as compared to current costs
7. Gutter materials – slight increase in costs as combustible gutter materials are eliminated in UWI zones.



Figure 1: Stucco-covered eave design on a survivor of the Cedar Fire.

2.2.2.1. Costs by Assembly

Using the increased costs developed and illustrated in the preceding text for affected items to find home costs, an assessment of pass-through costs from builders to

homeowners and overall cost increases were developed and potential cost increases by assembly types are commented on here:

For exterior deck surfaces, the costs to enclose a deck will be entirely related to the nature of the home design and material choices. A deck on a level site is almost by definition built at grade, while decks on sloping sites invariably include areas that are above grade with resultant fire performance hazard issues.

Adding cladding to such decks to enclose areas where ignition might occur will add to home costs. For example, if stucco were used to accomplish this, additional costs would be in the range of \$5.87 to \$7.29 per square foot if stucco skirting was used with and without the use of sheathing respectively. If a home was sided with hardboard and similar skirting were added to a deck design, costs in the range of \$4.71 to \$3.29 would be added with and without the use of sheathing respectively.



Figure 2: Stucco-covered eave design on another residence that survived the Cedar Fire.

Thus for a 10’ x 20’ deck [with an added 2 foot skirt for 30 linear feet], 60 square feet of skirting materials would need to be added. This could increase costs in the range of a low-cost estimate of \$234.00 for painted hardboard siding to a high-cost estimate of \$438.00 for colored stucco over plywood sheathing.

Cost increases for roof eave designs and new venting approaches are difficult to estimate. A typical 1,750 square foot ranch home can include 226 linear feet of eaves¹⁶. Costs for possible eave construction methods can be represented as follows:

Open wood eaves at – \$15.28/lineal ft	\$3453.28 eave cost
Closed wood eaves at – \$19.37/lineal ft	\$4377.62 eave cost
Closed stucco eaves at – \$33.26/lineal ft	\$7516.76 eave cost

¹⁶ See appendix V for details of baseline home measurements used in these calculations

Thus the choices for eaves for the hypothetical home will hinge in large part on siding chosen. In any case, increases in home costs due to differences in costs to close out eaves will be between 25% and 33% of the base cost of an open eave.

Gutter costs for the 216 feet of eaves on the hypothetical home would increase as follows:

5" vinyl at \$4.86/foot	\$1049.76 gutter cost
5" aluminum at \$5.11/foot	\$1103.76 gutter cost
5" steel at \$5.17/foot	\$1116.72 gutter cost

2.2.2.2. Overall Economic Impact on Typical Home Costs

Overall costs for typical homes on a statewide basis have been evaluated. Available figures are reflected in the following table:

Table 4: Issuance of Building Permits in California & Construction Values¹⁷

Year	Permits Issued for Single Family Dwellings	Total Valuation (\$billions)	Value/Permit Issued	Value/SF for 1750 Home
2001	106,902	21,005,609	196,494	\$112
2002	123,865	24,873,477	200,407	\$115
2003	138,762	28,211,949	103,311	\$116

The numbers above suggest that an average home built in UWI areas over the last 3 years costs around \$200,000 or \$115/sq ft.

Pass-through costs to builders and homeowners and average amortized margins available to developers associated with the proposed regulations, for the average 1750 square-foot home, based on the construction assemblies discussed above, estimated costs will result in increased as follows under the new regulations:

For deck closure & misc. detailing	\$500.00 increase
For closure of soffitts	\$925.00 increase
For increases in gutter costs	\$100.00 increase
Total increase for 1750 SF house (based on new regulations)	\$1,525.00 increase

¹⁷ Data from the Construction Industry Research Board, 2511 Empire Av, Burbank CA. Monthly building Permit Series; Supplement to Calif. Construction Review, Std. 6.23.04.

On a square foot basis, this can be expressed as an additional \$0.87 per square foot to meet the requirements of the new regulations, as compared to the original cost of \$115 per square foot.

Increases are occurring from year to year in overall value per home and cost per square foot in the data table above is for the years 2001 –2003. The magnitude of these reflects the increasing values of homes and costs of building. The increases for the proposed fire safety features are well under these increases in value.

If one takes the projected baseline increase per home of \$1525.00 and adds 40% for developer overheads, the total becomes \$2135. If amortized over the typical financing period for new homes of 30 years, this figure is \$71.17/year over the 30-year period or an increase of \$0.04 per square foot for the baseline home size of 1750 square feet.

2.3. Insurance industry and insurance-related issues

This analysis reviews the role of insurers in reducing the exposure of wildland fire hazards.^{18,19,20,21}

2.3.1. Perspective

The Insurance Services Office has maintained a database of insurance payments in the United States due to wildfires and other catastrophes since 1970. During the 1970s and 1980s there were eight major wildfires, which led to insurance payments of between \$5 and \$43 million for each event, or adjusted for inflation, payments between \$10 and \$100 million²². Between 1990 and 1993, there were four enormous fires in California which led to several thousand insurance payments totaling \$265 million to \$1.7 billion for each event or, adjusted for inflation, a total payment of \$3 billion.

While these losses focused industry attention on wildfires, they are small when compared to the multi-billion dollar industry losses from Atlantic hurricanes and California earthquakes. However, insurers are now recognizing the significance of wildland fires and factors that increase the risk of damage from wildland fires. This new focus is partly due to the increasing number of people and properties at risk.

¹⁸ Institute for Catastrophic Loss Reduction, Insurance Bureau of Canada January 2001. Available at: www.dels.nas.edu/dr/docs/kovacs.pdf.

¹⁹ Partners in Protection, FireSmart Protecting Your Community from Wildfire, Partners in Protection, 1999. Available at: www.partnersinprotection.ab.ca.

²⁰ Fundamentals of Risk and Insurance. Vaughn, Emmett. John Wiley & Sons Inc. 2003.

²¹ Rodda, Cynthia, 2002. Proceedings of the California's 2001 Wildfire Conference: Ten years after the East Bay Hills Fire. October 10-12 2001. Technical Report 35.01.462. Richmond Ca. University of California Forest Products Laboratory.

²² ISO Insurance Issues Series, The Wildland/Urban Fire Hazard, Insurance Services Office, 1997.

“There are now an estimated 12.2 million people living on the edge of Western forests. The rate of building at the forest fringe is growing 25% faster than for construction elsewhere in the landscape.”²³

In a market-driven industry, developers will build where the demand is highest, and contractors will build the home customers ask for. The common perception is that many people moving to the mountains do so with a vision of a home built of wood, so as not to disrupt the landscape around it. Builders fear they could lose business if they push too hard to sell homebuyers higher-priced, fire-resistant building materials, such as clay roofing tiles and composite siding.

Fuel management, adoption and enforcement of stricter building codes and education of the property owner are critical tools to address this problem. There are few restrictions, such as zoning regulations or prohibitive insurance premiums, which discourage or prevent homes from going up in the midst of trees.

Only 24 of the 3,600 homes lost in the California Wildland Fires of 2003 were in Ventura County. According to FEMA²⁴, this is due to their strict vegetation control by both property owners and the Ventura County Fire Department. For the last 37 years, Ventura County has required all property owners to remove all brush and debris within 100 feet of their home. If the homeowner chooses not to comply, the county sends contractors to clear the land for them; the homeowner must pay the bill, which includes a \$635 administrative fee. The county is forced to clear out only about 30 properties a year out of 15,000 notices that are sent out annually. The county’s Board of Supervisors enforces the program.

2.3.2. Role of Insurers in Wildfire Risk Management

The fundamental tool for insurers in managing wildfire exposure revolves around the choices that insurers face in underwriting properties exposed to the wildland fire hazard. The elements to this process include:

- Developing and implementing appropriate underwriting guidelines
- Measuring and managing the aggregate amount of wildfire exposure in an insurer's book of business
- Managing the geographic distribution of exposures to prevent excessive concentration in any single area or contiguous areas prone to wildfires
- Educating insurers and agents about loss mitigation

The insurance industry is increasingly turning to technology for wildfire risk management. Various products that combine street maps, satellite maps that measure fuel density, and topographical maps showing slope, elevation and severe weather frequency assist the insurance industry in underwriting high-value wildfire risk, based on accurate measures of risk.

²³ Los Angeles Times; May 22, 2002.

²⁴ “The California Fires Coordination Group: A Report to the Secretary of Homeland Security”; FEMA, 2/13/2004.

Interviews with underwriting professionals for three of the largest homeowner carriers in California (State Farm, Allstate and AAA) indicate that underwriting criteria vary from company to company as they apply to the elements outlined above. Eligibility for coverage is generally dependant on well-known factors that currently include:

- Prior loss experience
 - Fire
 - Other perils
- Defensible space
 - Flammable vegetation at least 30' from structures [100 feet preferred]
 - Slope of hillside
 - Debris removed from roof
 - 15 foot vegetation separation
 - 15 foot trimming of branches
- Suppression
 - Protection class
 - Access – Road width
- Water source
 - Distance
 - Municipal
- Fire resistive
 - Roof

The application of these guidelines is necessarily subject to the individual insurer's decision regarding market factors and exposure to loss. As harshly noted by one underwriting professional, "It is key to note that not all insurance companies look at all or even some of the above factors. They either don't recognize any of the above as being indicators for loss and use other factors, have such a large book of business that they are willing to take on the unknown, or simply don't care." [Proceedings of the California's 2001 Wildfire Conference]

If a residential risk is ineligible for coverage due to brush fire peril, the homeowner must turn to the FAIR Plan [Fair Access to Insurance Requirements.] Section 10090 of the California Insurance Code sets out the legislation creating the FAIR Plan.

10090. The purposes of this chapter are to do all of the following:

(a) To assure stability in the property insurance market for property located in the State of California.

(b) To assure the availability of basic property insurance as defined by this chapter.

(c) To encourage maximum use, in obtaining basic property insurance, of the normal insurance market provided by admitted insurers and licensed surplus line brokers.

(d) To provide for the equitable distribution among admitted insurers of the responsibility for insuring qualified property for which basic property insurance cannot be obtained through the normal insurance market by the establishment of a FAIR Plan (Fair Access to Insurance Requirements), an industry placement facility and a joint reinsurance association.

The largest incentive to manage this risk may come through concerns about availability of coverage. For example:

“Over the next few years, some 1,200 State Farm customers in Wyoming’s wildfire-prone areas must create ‘defensible space’ around their homes or risk losing home insurance coverage.

Those homeowners represent about one-fifth of the 21,000 State Farm customers in six Western states whose homes are considered to be in high-risk areas for catastrophic wildfires. Next month, the company begins inspections, looking at customers’ properties and high-risk conditions for wildfire.”²⁵

2.4. Costs and Relative Benefits Accruing from Issuance of Regulations

By applying the data developed in the preceding sections, we can develop *estimates* of sector wide changes to costs of building in the UWI if the proposed SFM regulations are approved.

Earlier, data was presented illustrating that construction volume in the range of \$280 billion took place in 2003 for 140,000 new single-family dwelling units.

We can also estimate that if the UWI occupies 10% of the state’s construction sector in single-family dwellings, then construction at the UWI can be valued at \$28 billion for 14,000 new homes.

The preceding calculations also indicated that, after a 40% markup for developer’s overhead, the average housing cost will increase by \$2135 per home. With the proposed regulations for the estimated 14,000 new homes being built in UWI areas, the total increase will be in the range of \$29,890,000.

These figures represent potential annual increases in costs to build homes in designated high fire hazard–severity areas. They provide a snapshot based on 2003 construction statistics if the proposed State Fire Marshal’s construction regulations are adopted.

Consistent with the figures above, note that valuations of single family dwellings constructed from 2001 through 2003 increased an average of \$3-\$4 billion *per year* as a function of increases in costs of construction and value to purchasers. These levels of annual increases are *two orders of magnitude greater* than the projected costs of the proposed regulations.

2.4.1. Costs of Not Adopting the Proposed Regulations

As with all regulations affecting new construction, adoption of the proposed regulations cannot be expected to be reflected in overnight changes in the California economy. Given that a large inventory already exists of homes built using construction techniques and materials that would not pass muster by the proposed regulations, their performance

²⁵ Casper, Wyoming Star-Tribune. May 24, 2003.

remains suspect, although mitigation efforts by local AHJ's and educational programs could be expected to provide some measure of upgraded performance. However, such issues are outside the scope of this report.

In 2003 for example the six wildland fires considered in this report which included urban interface components resulted in \$2.03 billion in property damage. The Oakland Hills fire in 1991 and the UWI fires of 1993 in Southern California also resulted in property losses in the billions of dollars. In addition, these incidents necessitated expenditures for fire fighting activities in the hundreds of millions of dollars. No change is likely to take place in the trend of these losses without establishing new minimum standards for construction in UWI areas. It is also obvious that average annual losses in the range of 2-4 billions of dollars will continue to take place in California. State and Federal sources will be footing much of the bill. The private sector will be affected in terms of increased insurance premiums along with the rise in materials and labor costs needed for re-construction. All this will compete with already scarce dollars for investment in new housing starts.

It may be argued that the estimates developed earlier underestimates increases – particularly for a given set of construction details - by a factor of two to four. The cost of pro-actively addressing these problems through regulations, however appears to provide a significant advantage over waiting for the fires to occur and then spending more for emergency response, disaster relief and re-construction.

3. Conclusions

If no action is taken, the magnitude of the costs Californian citizens will have to face year after year from fires in UWI areas can be expected to increase.

The damage from the Southern California Fires of fall 2003 has been reported as totaling \$2.04 billion in property losses to the private sector and well in excess of \$150 million in suppression costs from the public sector resources.

The insurance industry has acknowledged the reality of the “Urban-Wildland interface problem” as it relates to the perils of fire. Underwriting and educational efforts to manage the exposure continue but are hampered by market forces within the insurance industry and without. These are reflected both in competition between carriers and market entry and exit decisions.

The building and banking industries require the existence of insurance for the perils of fire. The insurance industry would clearly benefit from external forces demanding the use of risk management techniques that have proven effective. Harnessing the loss exposure would create a more favorable loss experience upon which to base future rates. This favorable loss experience would have a deflationary effect on that component of insurance premium.

As noted, it is obvious that the value and effect of the regulations proposed for adoption will not be felt in the first year or two. However, over time, much like changes in insurance rates, if mitigation efforts are instituted continually and their effects demonstrated – their impact will accrue. Logically, as with requirements to add smoke detectors to homes or regulate high rise fire safety at the state level, the cumulative value will be much like having built a fence at the top of a cliff as opposed to dispatching an ambulance every time some one falls off the cliff.

Potential benefits of the proposed regulations are considerable. The technology is not exotic nor is it expensive. It is anticipated that the results will benefit all involved sectors in the State of California.

4. Appendices

4.1. Appendix I– Direct and Indirect Employment Resulting from Residential Construction in California.

New Housing Construction Employment in California

Sector Name	Total Industry Employment			
	Direct Impact	Indirect Impact	Induced Impact	Total Impact
California Total	239,440	145,251	141,285	525,976
New residential 1-unit structures- nonfarm	194,916	-	-	194,916
New multifamily housing structures- nonfarm	44,524	-	-	44,524
Wholesale trade	-	11,985	6,150	18,135
Food services and drinking places	-	1,397	16,241	17,637
Food and beverage stores	-	9,988	4,011	13,999
Architectural and engineering services	-	11,231	475	11,706
General merchandise stores	-	5,623	3,852	9,475
Employment services	-	6,239	2,475	8,714
Miscellaneous store retailers	-	6,025	2,359	8,384
Offices of physicians- dentists- and other health	-	-	8,092	8,092
Building material and garden supply stores	-	6,231	1,690	7,921
Health and personal care stores	-	6,152	1,420	7,572
Motor vehicle and parts dealers	-	3,933	3,372	7,305
Nonstore retailers	-	3,447	3,025	6,472
Sporting goods- hobby- book and music stores	-	4,512	1,329	5,841
Hospitals	-	-	5,762	5,762
Real estate	-	2,032	3,566	5,598
Clothing and clothing accessories stores	-	2,743	2,321	5,064
Truck transportation	-	3,505	1,039	4,544
Wood kitchen cabinet and countertop manufacturing	-	4,369	56	4,425
Automotive repair and maintenance- except car wash	-	1,679	2,699	4,377
Nursing and residential care facilities	-	-	4,052	4,052
Electronics and appliance stores	-	3,339	667	4,006
Securities- commodity contracts- investments	-	1,385	2,354	3,739
Services to buildings and dwellings	-	2,217	1,466	3,683
Legal services	-	1,755	1,813	3,568
Private households	-	-	3,475	3,475
Accounting and bookkeeping services	-	2,292	1,131	3,422
Social assistance- except child day care services	-	1	3,307	3,308
Management of companies and enterprises	-	1,818	1,119	2,937
Civic- social- professional and similar organizations	-	1,069	1,810	2,879
Monetary authorities and depository credit intermediation	-	777	1,848	2,625

New Housing Construction Employment in California (cont.)

Sector Name	Total Industry Employment			
	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Insurance carriers	-	712	1,869	2,581
Plastics plumbing fixtures and all other plastics	-	2,030	241	2,271
Gasoline stations	-	1,281	987	2,268
Other amusement- gambling- and recreation industries	-	37	1,944	1,981
Furniture and home furnishings stores	-	877	1,075	1,952
Management consulting services	-	1,308	643	1,951
Couriers and messengers	-	1,405	541	1,946
Advertising and related services	-	1,060	710	1,770
Telecommunications	-	817	927	1,744
Hotels and motels- including casino hotels	-	599	1,142	1,741
Colleges- universities- and junior colleges	-	121	1,564	1,685
Investigation and security services	-	1,036	620	1,656
Business support services	-	957	697	1,654
Child day care services	-	-	1,649	1,649
Other ambulatory health care services	-	1	1,640	1,641
Nondepository credit intermediation and related	-	757	776	1,532
Elementary and secondary schools	-	-	1,481	1,481
Sawmills	-	1,420	33	1,453
Data Source: IMPLAN model outputs. Table shows only the first 50 sectors with the largest total impacts. SACTO-CSUS Sacramento Regional Research Institute, February 2004.				

4.2. Appendix II-Proposed UWI Building Standards

**CDF-SFM Draft
Code Change Proposal
Chapter 7A – July 12, 2004**

SECTION 701A [For SFM] FIRE-RESISTANT MATERIALS AND CONSTRUCTION METHODS USED WITHIN WILDLAND AREAS

SECTION 701A -- SCOPE

This chapter applies to building materials and systems used in the exterior design and construction of buildings and structures located within:

- a) State Responsibility Areas designated as Very High Fire Hazard Severity Zones by the Director of Forestry and Fire Protection pursuant to Article 9 (commencing with Section 4201) of Chapter 1 of Part 2 of Division 4 of the Public Resources Code.
- b) Very High Fire Hazard Severity Zones designated by a local agency pursuant to Chapter 6.8 (commencing with Section 51175) of Part 1 of Division 1 of Title 5 of the Government Code.
- c) Urban Wildland Interface Communities and other areas designated by a local agency pursuant to Health & Safety Code 13108.5.

SECTION 702A – PURPOSE

The purpose of this code is to provide minimum standards to increase the ability of a building or structure to resist the intrusion of flame or burning embers through the use of performance and prescriptive requirements in accordance with the authority provided in Government Code §51189 A.

SECTION 703A -- FIRE RESISTANT MATERIALS AND SYSTEMS

703A.1 General.

Materials and systems used for fire-resistant purposes shall be in accordance with this Chapter.

703A.2 Qualification By Testing

Material and material assemblies tested in accordance with the requirements set forth in 704A.3 shall be accepted for use in accordance with the results and conditions of such tests. Testing shall be performed by a testing agency approved by the Authority Having Jurisdiction.

703A.3 Standards of Quality.

The SFM standards listed below are also listed in Chapter 35, Part III and are part of this code. The Authority Having Jurisdiction may use other standards that are equal to or exceed standards listed in this chapter.

The standards listed below are adopted by the State Fire Marshal and are listed in Chapter 35.

SFM-1 EXTERIOR WALL TEST STANDARD
SFM-2 EXTERIOR WINDOW TEST STANDARD
SFM-3 UNDER EAVE TEST STANDARD
SFM-4 ROOF ASSEMBLY TEST STANDARD
SFM-5 DECK TEST STANDARD

SECTION 704A -- ROOFS

704A.1 General.

All roof assemblies shall provide protection in accordance with SFM-4 “Roof Assembly Test Standard” and Chapter 15. This requirement shall also apply to non-combustible roof coverings specified in Chapter 15.

704A.2 Roof Spaces and Openings

For roof coverings where the profile allows a space between the roof covering and roof decking, the spaces shall be constructed to prevent the intrusion of flames and embers.

NOTE: Use of one layer Type 72 ASTM cap sheet shall meet the intent of this section.

704A.3 Roof Valleys

Roof valleys shall be protected with metal flashing having a minimum 36 inch (914 mm) wide underlayment consisting of one layer of Type 72 ASTM cap sheet running the length of the valley.

704A.4 Roof Vents

Roof and attic vents shall resist the intrusion of flame and embers into the attic-area of the structure.

NOTE: Roof and attic vents protected by corrosion resistant and non-combustible screening material with ¼ inch (6 mm) openings shall meet the intent of this section.

704A.5 Eave Protection

Eaves and soffits shall meet the requirements of SFM-3 “Under Eave Test Standard” or shall be protected by materials approved for one-hour fire resistive construction on the exposed underside as approved by the Authority Having Jurisdiction.

704A.6 Skylights

Skylights shall be constructed of tempered glass, multi-layered glazed panels, or those materials approved by the Authority Having Jurisdiction.

EXCEPTION: Structures protected throughout by an approved automatic sprinkler system.

704A.7 Roof Gutters and Downspouts

Roof gutters and downspouts shall be constructed of non-combustible materials.

SECTION 705A – EXTERIOR WALLS

705A.1 General.

All wall assemblies shall provide protection from the intrusion of flames and embers in accordance with SFM-1 “Exterior Wall Test Standard”

EXCEPTIONS:

A. Exterior wall surface material must have an underlayment of ½ inch (12.7 mm) fire rated gypsum sheathing that is tightly butted, or taped and mudded, under 3/8 inch (9.5 mm) plywood or ¾ inch (19 mm) drop siding or an approved alternate. Exterior wall coverings shall extend from the top of the foundation to the underside of the roof sheathing, terminate at 2 inch nominal solid wood blocking between rafters at all roof overhangs, or in the case of enclosed eaves, terminate at the enclosure. The requirements of this exception shall satisfy the intent of Section 705A.1 as an alternate means of protection.

B. Non-combustible material, heavy timber or log wall construction

705A.2 Exterior Wall Openings.

Exterior wall openings shall be in accordance with this section.

705A.2.1 Exterior Glazing

Exterior windows, window walls, glazed doors, and windows within exterior doors shall conform to the performance requirements of SFM-2 “Exterior Window Test Standard.” The installation of tempered glass, multilayered glazed panels, glass block or other window assemblies having a fire protection rating of not less than 20 minutes shall meet the intent of this section.

705A.2.2 Doors

Exterior door assemblies shall conform to the performance requirements of SFM-1 “Exterior Wall Test Standard.” Alternatively, exterior doors shall be an approved non-combustible construction, solid core wood not less than 1-3/4 inches (44 mm) thick, or have a fire protection rating of not less than 20 minutes to meet the intent of this section.

EXCEPTION: Vehicle access doors.

705A.2.3 Windows within Doors

Windows within doors and glazed doors shall be in accordance with Section 700A.5.2.1.

705A.2.4 Wall Vents

Vent openings in exterior walls shall resist the intrusion of flame and embers into the structure.

NOTE: Vents shall be screened with a corrosion-resistant, non-combustible wire mesh with a ¼ inch (6 mm) opening except where not permitted elsewhere in this code and be a minimum of 10 feet from the property line. Underfloor ventilation openings shall be located as close to the ground as practical. This requirement shall meet the intent of this section.

705A.3 Appendages and Floor Projections

The underside of cantilevered and overhanging floor projections shall maintain the fire resistive integrity of the exterior walls or the projection shall be enclosed to the ground with exterior walls in accordance with Section 705A.2.

705A.4 Unenclosed Underfloor Protection

Buildings or structures shall have all underfloor areas enclosed to the ground with exterior walls in accordance with Section 705A.1.

EXCEPTION: Complete enclosure may be omitted where the underside of all exposed floors and all exposed structural columns, beams and supporting walls are protected as required for exterior one-hour fire resistance rated construction. Heavy timber, 2 inch nominal redwood heartwood, fire retardant treated wood or non-combustible materials shall meet the intent of this section.

706A ANCILLARY STRUCTURES

706A.1 Decking

Decks and similarly constructed horizontal structures within 10 feet of the habitable structure shall comply with the performance requirements set forth in SFM-5 “Deck Test Standard.”

EXCEPTION: Decking of heavy timber, 2 inch nominal redwood heartwood, fire retardant treated wood or non-combustible materials shall meet the intent of this section.

706A.2 Ancillary Structures

All ancillary and detached accessory structures shall comply with the performance requirements set forth in this code as determined by the Authority Having Jurisdiction.

URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

EXTERIOR WALL SIDING AND SHEATHING STANDARD SFM-1

STATE FIRE MARSHAL

- (a) **Application.** *The minimum design, construction and performance standards set forth herein for exterior wall siding and sheathing are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A.*
- (b) **Scope.** *This standard determines the performance of exterior walls of structures when exposed to direct flames.*
- (c) **Referenced documents.**
1. *ASTM D4444. Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters*
 2. *ASTM D 2898. Standard Test Methods for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing*
 3. *California Building Code, Chapter 7A*
- (d) **Definitions**
1. **Cladding.** *Any material that covers an interior or exterior wall*
 2. **Sheathing.** *The outside covering used over the wall framework and is nailed directly to the wall framing members.*
- (e) **Equipment**
1. **Burner.** *A 4 x 39 in. (100 x 1000 mm) propane diffusion burner shall be used.*
 2. **Infrared temperature analyzer (optional).** *Intended for monitoring the temperature change of the inside of the sheathing material.*
 3. **Moisture meter.** *For measurement of moisture content of framing.*
- (f) **Materials**
1. **Cladding.** *Material selected for the test*
 2. **Sheathing (optional).** *4- x 8-ft (1.2- x 2.4- m) sheet*
 3. **Framing.** *2 x 4 studs*

(g) Test system preparation (Figure 1).

1. **Wall Module.** The module shall be designed to permit rapid installation and removal of wall assemblies and have two adjustable non-combustible sidewalls, and a non-combustible simulated soffit. The module shall permit insertion of a prefabricated 4 x 8 ft (1.2 x 2.4 m) wall section.
2. **Framing.** Frame the wall assembly with 2 x 4 studs, typically 16 in. (410 mm) on center.
3. **Moisture content.** Measure the moisture content of the wooden members of the assembly using a moisture meter (ASTM D4444)
4. **Sheathing.** Add sheathing material (optional). If sheathing is used, tests must be run on nominal 0.5-in (12 mm) oriented strandboard of Exposure 1 rating. Any other sheathing may be run, but must be reported. The sheathing must have one seam on a selected stud with a 0.125-in. (3 mm) gap.
5. **Cladding.** Attach the chosen cladding according to the cladding manufacturer's directions. All potential cladding joints that may be present in a typical wall must be incorporated into the assembly.
6. **Other materials.** Other components of the wall assembly, such as building felt and sheathing, are chosen to meet the manufacturer's specifications and/or local building codes. Cavity insulation is not to be used.
7. **Sealing.** Seal the top and side edges of the installed wall with ceramic wool or comparable material to prevent flame penetration at the edges.
8. **Finish.** The wall should be finished in a manner appropriate for exterior exposure as specified by the manufacturer.

(h) Pretest Weathering (optional).

1. **Number of test assemblies.** Prepare six assemblies of which three shall be randomly selected for the weathering exposure. The remaining three assemblies shall be tested as unweathered controls.
2. **Preparation.** The back of the wall assembly must be protected from water penetration by stapling or taping a 4 x 8 ft (1.2 x 2.4 m) sheet of polyethylene film to the outside of the framing members (the side opposite the cladding) to protect the interior of the wall cavity from being wetted by overspray.
4. **Weathering.** Subject the assembly to the 12-week wetting-drying weathering exposure defined in ASTM D 2898, Method A, with the following modifications:
 - i. The assembly shall be mounted vertically.
 - ii. The heating cycle shall consist of air heated at $125 \pm 5^{\circ}\text{F}$ ($50 \pm 2^{\circ}\text{C}$) impinging on the wall at 10 mph (17 km/h or 4.5 m/s).
 - iii. An ultraviolet exposure shall be used during the weathering exposure, with the lamps activated during the 72-h drying cycles. Installation and exposure details regarding the sunlamps shall be as described in ASTM D 2898, but shall be modified for a sample having a vertical orientation.
 - iv. The polyethylene film shall be removed after weathering is completed.
4. **Conditioning.** Prior to testing, the weathered wall assemblies shall be stored for at least 2 wk indoors with good air circulation at temperatures between 60 and 90°F (16 to 32°C) to allow excess moisture to evaporate.

(i) Conduct of Tests.

1. **Airflow.** The wall test shall be conducted under conditions of ambient airflow.
2. **Number of tests.** Conduct the tests on three replicate wall assemblies (six for weathered performance).
3. **Burner output verification.** Without the wall assembly in place, adjust the burner for 150 ± 8 kW output. Extinguish the burner.
4. **Burner configuration.** Center the burner relative to the width of the cladding-wall assembly and 0.75 in. (20 mm) from the wall. The distance from the floor to the top of the burner shall be 12 in. (300 mm).
5. **Procedure**
 - i) Ignite the burner, controlling for constant 150 ± 8 kW output.
 - ii) Continue the exposure until flame penetration of the cladding-wall assembly occurs, or for a 10-min period.
 - iii) If penetration does not occur, continue the test for an additional 60 min or until all combustion has ceased. An infrared thermometer has been found to be useful to detect the increase of temperature on the back side of the sheathing and an aid to identify the areas of potential combustion.
6. **Observations.** Note the time, location, and nature of flame penetration

(j) Report. The report shall include a description of the wall cladding, sheathing material, details of the construction of the subassembly, details of the cladding installation, moisture content of the framing, whether the weathering test was conducted, and where flame penetration of the wall occurred. Provide details on the time and reasons for early termination of the test.

(k) Conditions of Acceptance. Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.

1. Absence of flame penetration through the wall assembly at any time.
2. Absence of evidence of glowing combustion on the interior surface of the assembly at the end of the 70-min test.

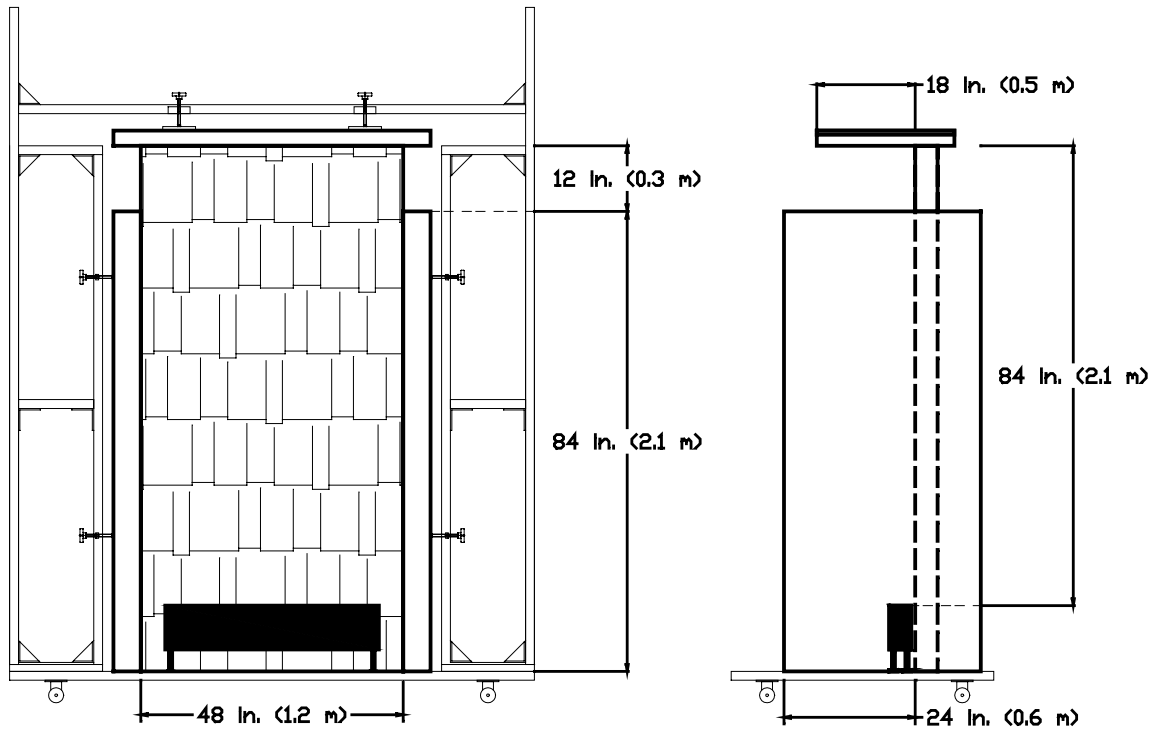


Figure 1. Exterior Wall Test Assembly

Commentary: Exterior Walls

Purpose.

This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to “certify” materials and/or assemblies, but to provide guidance in the development of the test protocols and for the “conditions of acceptance.” Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.

Exterior walls are exposed to convective and radiant heat from an approaching wildfire and to ignition of flammable materials (plants, trash, a deck or shed, etc.) that might be adjacent to a building. However, the preponderance of evidence is that convective and radiant heat are minor factors in UWI fire impact on exterior walls.

There are two major concerns for walls having combustible cladding:

1. Ignition directly (radiation, convection, flame contact) or indirectly (combustion of materials near the base of the wall), followed by penetration into the wall cavity (directly or indirectly through the wall assembly, or through seams) and then into the building.
2. After ignition, vertical flamespread to windows, eaves, or upper ancillary structures, and subsequent penetration of the structure.

For non-combustible cladding, the major concern is conductive heat transfer through the wall cavity that can ignite studs or other wall cavity materials. Also, for materials having seams, there is a possibility of penetration via these openings.

Wall assembly.

The wall assembly test module (Figure 1 in the Standard) permits rapid installation and removal of 4- × 8-ft (1.2- × 2.4-m) wall assemblies, and is designed to prevent penetration of fire at the panel edges. The side enclosure and soffit provide shielding from ambient air currents and permit normal eddy currents to occur, respectively. The wall assembly did not have insulation or sheathing on the back side in order to permit visual and infrared observation of combustion or temperature build-up on the back side.

Development of the Test Protocol

Since ignition by ornamental plants (or equivalent combustibles) is the most probable source of flame impingement of walls, a number of tests were run to determine the likely intensity and duration of exposure from small to medium size plants. From these tests (and other sources of research), the decision was to use a 150-kW line burner for a 10-min exposure. The exposure time was determined by field reports on the maximum length of time that a structure would be subjected to this level of intensity.

Tests

Materials. Tables 1 and 2 give the cladding and sheathing materials used in the preliminary tests. All sheathing was 0.5-in (12-mm nominal thickness. These materials were selected as representative of use on structures in California. Because of limitations in equipment and scope, it was not possible to test stucco cladding, but wood fiber-cement materials also have a conductive mode of heat transfer.

Assemblies. All wall assemblies were framed with Douglas-fir 2 x 4s, 16 in. (410 mm) on center. For cladding, seams were included that would be representative of a typical wall. For the horizontal lap cladding products, the patterns included plain bevel, rabbetted bevel, and shiplap. The vertical joints in panelized cladding products were either shiplap or simple butt-joints. Sheathing, when used, was either OSB or plywood, and with and without a butt joint.

Test procedure. The 10-min 150 kW exposure was used for the cladding-sheathing combinations, followed by an additional 60-min observation to detect any smoldering combustion (Table 1). The use of infrared photography of the back of the test wall was used to reveal development of increasing temperatures or persisting hot spots. Other tests (Table 2 and 3) were run on solely cladding or sheathing, where the burner was left on until failure to determine the weak points in various materials. Since no sheathing was used in cladding tests, shingles, which are nailed to sheathing, could not be included.

Results. Most of the cladding-sheathing assemblies (Table 1) had acceptable performance. However, the hardboard cladding failed because it burned vigorously and warped away from the sheathing, exposing it to flames. Likewise, the fire-retardant treated redcedar shingles quickly deformed and lifted off the sheathing. This test was terminated early (13 min) because of the acrid smoke, but since combustion was sustained, it was estimated that this wall would have burned through within 20 min.

For the cladding-only tests (Table 2), flame penetration occurred at joints for “combustible” cladding. The exception was wood fiber-cement cladding, for which in one case intermittent flame penetration was first seen at a crack in the panel, while in another, conducted heat ignited a stud behind the cladding. Flammability was clearly a major factor in cladding performance, as can be seen in the dramatic improvement in western redcedar cladding when it was fire-retardant treated with a chemical that had intumescent properties. It should be noted that the overlap was also much greater (1.5 vs 0.5 in.; 37 vs 12 mm) with this product, adding further protection against vertical flame penetration.

Table 3 shows the results for the sheathing-only tests to compare OSB and plywood. In both cases (with and without joints) the OSB failed in about 80% of the time of plywood. The relative effect of joint vs no-joint was slightly greater—about 75% less time to failure with joints in both materials. The joints had openings of 3 mm in compliance with manufacturers’ recommendations.

Comments.

Since the tests were conducted to obtain data on a wide range of materials and combinations of materials, only single tests were run for each assembly. The nature of the cladding joints had a substantial effect on relative performance. Most vulnerable was the plain bevel, while rabbetted and shiplap joints were increasingly resistant to flame-through. Based on these results, tongue-in-groove cladding, although not tested, should also perform well. The other important factor in fire resistance of cladding was the material itself. When the joint type was similar, wood composites such as hardboard and OSB were more vulnerable to fire penetration than solid wood and wood fiber-cement products. The length of the recommended observation period (60 min) after the 10-min burner exposure was found to be important to assure the detection of smoldering combustion, such as occurred in the finger-jointed redwood with OSB sheathing (Table 1). In UWI fires, the persistence of smothering combustion could lead to loss of structures long after they might be considered safe.

The information in Table 2 is applicable to many earlier forms of building construction where panel sheathing was either not used or code requirements were less stringent than today. Cladding without sheathing was unable to pass the 70-min (total) test; four even failed during the 10-min burner exposure. Several of the cladding materials that failed (Western red cedar FRT, finger-jointed redwood with plywood, L-P OSB, and both Hardie products) were able to pass when backed with sheathing (Table 2). The wood-fiber cement cladding performance shows that sheathing can play a very important insulation role to prevent ignition of studs.

The “conventional wisdom” has been that ignition of the cladding leads to loss of the structure; however, it was apparent that combustible cladding over combustible sheathing can withstand a substantial fire exposure. However, if the combustible cladding causes vertical flamespread to windows or eaves, it is quite possible that this could lead to failure indirectly, whereas non-combustible cladding would not promote this scenario.

Conditions of Acceptance.

Based on the tests, the acceptance criteria listed in Standard SFM-1 were considered appropriate.

Table 1. Cladding over sheathing tests

Product description	Joint type	Sheathing	Flame-through (min)	Notes
Western red cedar shingles FRT	Multiple joints	OSB	20 (est.)	Flaming sustained after 10 min; term at 13 min (irritating fumes)
Western red cedar, FRT	Plain bevel	OSB	None	nominal 6 in. pattern-horizontal lap
Western red cedar, FRT	Plain bevel	Plywood (CDX)	None	nominal 6 in. pattern-horizontal lap
Collins Pine Hardboard	Rabbetted bevel	OSB	22	Penetration at lap joint & through horizontal lap sheathing joint
Collins Pine Hardboard	Rabbetted bevel	Plywood (CDX)	22	Penetration at lap joint & through horizontal lap sheathing joint
Redwood, finger-jointed	Rabbetted bevel	OSB	65	Glowing combustion continued nominal 8 in pattern horizontal lap until sheathing penetrated
Redwood, finger-jointed,	Rabbetted bevel	Plywood (CDX)	None	nominal 8 in. pattern horizontal lap
Louisiana-Pacific OSB	Rabbetted bevel	OSB	None	horizontal lap
James Hardie wood fiber-cement (HardiePlank)	Plain bevel	OSB	None	horizontal lap
James Hardie wood fiber-cement (HardiePlank)	Plain bevel	Plywood (CDX)	None	horizontal lap
James Hardie wood fiber-cement (HardiePanel)	Vertical butt joint, panel	OSB	None	
James Hardie wood fiber-cement (HardiePanel)	Vertical butt joint, panel	Plywood (CDX)	None	

Table 2. Cladding-only tests

Product description	Joint type	Flame-through (min:s)	Notes
Western redcedar	Plain bevel horizontal lap	1:15	Failed at lap joint
Western redcedar, FRT nominal 6 in. pattern	Plain bevel horizontal lap	18:45	Failed at lap joint
Redwood, finger-jointed nominal 8 in. pattern	Rabbetted bevel horizontal lap	5:58	Failed at lap joint
Redwood nominal 6 in. pattern	Horizontal shiplap	21:18	Failed at lap joint
Laminated veneer lumber	Horizontal shiplap	15:40	Failed at lap joint
Plywood (T1-11)	Vertical shiplap, panel	22:15	Failed at lap joint
Louisiana-Pacific OSB	Rabbetted bevel horizontal lap	2:38	Failed at lap joint
Collins Pine Hardboard	Rabbetted bevel horizontal lap	3:20	Failed at lap joint
James Hardie wood fiber-cement (HardiePlank)	Plain bevel horizontal lap	21:35	Stud ignited
James Hardie wood fiber-cement (HardiePanel)	Vertical butt joint, panel	29:00	Failed at crack in panel

Table 3. Sheathing-only tests

Product description	Joint type	Flame-through	Notes (min:s)
Oriented strandboard	Vertical butt joint (on stud)	12:15	Failed at joint
Plywood (CDX)	Vertical butt joint (on stud)	15:20	Failed at joint
Oriented strandboard	No joint	16:30	Failed at stud
Plywood (CDX)	No joint	20:15	Failed at stud

URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

EXTERIOR WINDOWS STANDARD SFM-2

STATE FIRE MARSHAL

(a) Application. *The minimum design, construction and performance standards set forth herein for exterior windows are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A.*

(b) Scope. *This standard evaluates the performance of exterior windows used in structures when exposed to direct flames.*

(c) Referenced Documents.

5. *AAMA Training Manual, Residential & Light Commercial Window and Door Installation Training and Registration Program.*
2. *California Building Code, Chapter 7A*

(d) Definitions.

1. **Glazing.** *The glass in a window, which may include layers of plastic as well as glass.*
2. **Sash.** *The fixed or movable parts of the window in which the panes of glass are set.*
3. **Frame (Jambs).** *This usually consists of two vertical members (side jambs) and two horizontal members (head and sill) that hold the sash.*

(e) Equipment.

1. **Burner.** *A 4 x 39 in. (100 x 1000 mm) propane diffusion burner shall be used. For windows wider than 39 in. (1 m), the burner width should be increased to match the window width.*
2. **Infrared temperature analyzer** (optional). *Intended for monitoring the temperature change of the inside of the window assembly.*

(f) Materials. *In the absence of the window manufacturer's specifications, the wall assembly shall include the following minimum components:*

1. **Windows.** *The window may be any type or size that fits within the wall (see (g).1.ii).*
2. **Framing.** *2 x 4 studs*
3. **Gypsum board.** *Non-combustible mounting around the window.*
4. **Gypsum trim.** *Pieces of gypsum cut into narrow strips for use as trim around the window.*
5. **Caulk.** *Caulking to be applied as per the window manufacturer's instructions.*

(g) Test system preparation (Figure 1).

1. **Wall Module.**

- i). The module shall be designed to permit rapid installation and removal of window/wall assemblies and have two non-combustible side walls, and a non-combustible simulated soffitt.
- ii). The assembly shall permit rear insertion of a pre-fabricated 4 x 8 ft (1.2 x 2.4 m) wall section containing the test window. The bottom edge of the window shall be 24 in. (450 mm) from the top of the burner.
- iii) Larger windows may be tested by expanding the size of the rear wall of the Wall Module, and the length of burner.
- 2. **Window framing.** Provide a framed rough opening following manufacturer guidelines. Apply manufacturer recommended caulk to nailing flange prior to installation.
- 3. **Window installation.** Fit the window into the rear wall of the Wall Module, referring to AAMA Training Manual or equivalent.
- 4. **Sealing.** Seal all edges, including the soffitt-to-wall joint using ceramic wool or comparable material to prevent flame penetration at the edges.
- 5. **Trim.** Use narrow strips of gypsum board as trim around window, covering the nail flange of the window.
- 6. **Finish.** Apply finish to exposed portion of window frame if recommended by window manufacturer.

(h) Conduct of Tests.

- 1. **Airflow.** The window test shall be conducted under conditions of ambient airflow.
 - 2. **Number of tests.** Conduct the tests on three replicate window assemblies.
 - 3. **Burner Output Verification.** Without the window in place, adjust the burner for 150 ± 8 kW output. Extinguish the burner.
 - 4. **Burner configuration.** Center the burner relative to the width of the window-wall assembly and against the wall. The distance from the floor to the top of the burner shall be 12 in. (300 mm).
 - 5. **Procedure.**
 - i). Ignite the burner, controlling for a constant 150 ± 8 kW output.
 - ii). Continue the exposure until flame penetration or structural collapse occurs, or for a 10-min period
 - iii). If penetration or collapse does not occur, continue observation for an additional 30 min or until all combustion has ceased. An infrared thermometer has been found to be useful to detect the increase of temperature on the back side of the windows and an aid to identify the areas of potential combustion.
 - 6. **Observations.** Note the development of any fissures or holes in the frames or glazing, and time and location of any penetration of flames through frames or glazing.
- (i) Report.** The report shall include a description of the window unit, including the types of frames, cladding and panes being tested, and details of the installation. Record when and how the glass fractured or flame-through occurred in the framing materials or sash, and/or if the framing material deformed or otherwise suffered a loss of integrity such that the glass could not be held in place, and a record of the time at which any of these events occurred. Provide details on the time and reasons for early termination of the test.

(j) Conditions of Acceptance. Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.

- 1. Absence of flame penetration of windows during the test.

2. Absence of structural failure of the frame or glazing, or gaps or fissures greater than 0.25 x 6 in. (6 x 150 mm).
3. Absence of flaming or glowing combustion of the framing at the conclusion of the 40-min test.

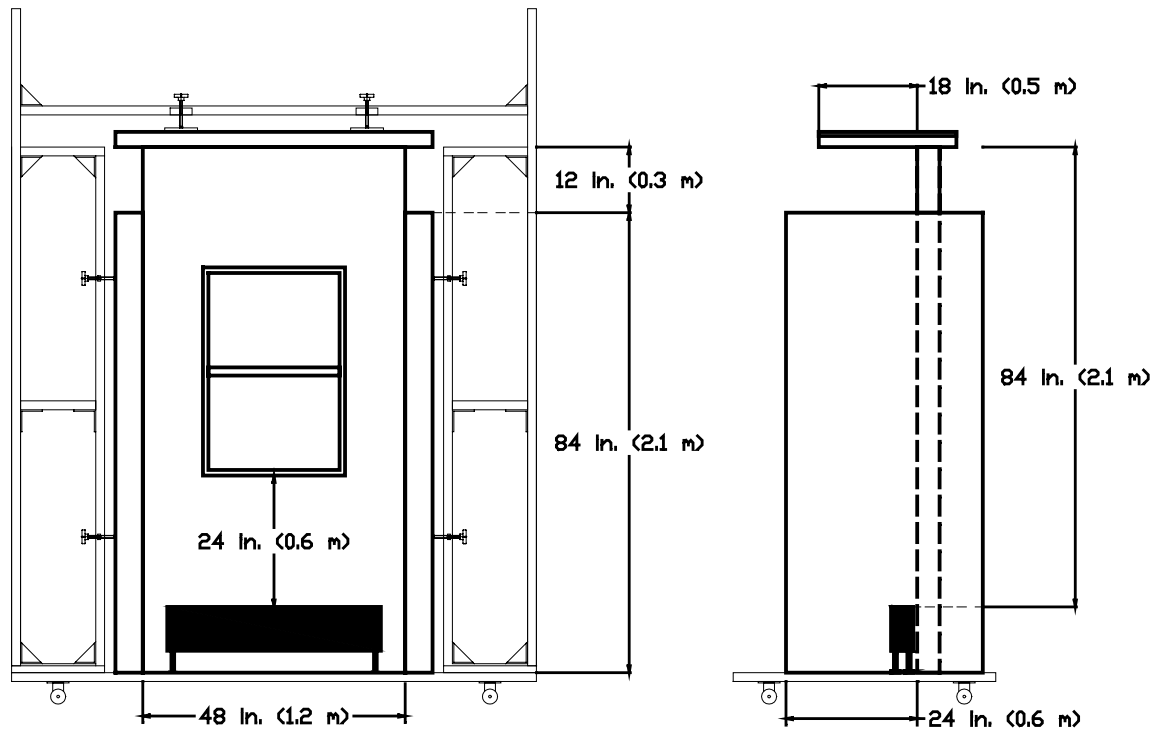


Figure 3. Window-Wall Test Assembly

COMMENTARY: EXTERIOR WINDOWS

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

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Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to “certify” materials and/or assemblies, but to provide guidance in the development of the test protocols and for the “conditions of acceptance.” Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.

Windows are one of the most vulnerable portions of a structure exposed to fire because of the possible loss of integrity, permitting brands or flames to gain entry. This vulnerability is due to a number of factors. Impact of airborne debris or the thermal shock of direct flame impingement may fracture the glass, permitting burning brands or flames to gain entry into the building. The window frame is also susceptible to burn-through under direct flame exposure. Radiant or convective heating--from an adjacent burning structure, for example--might not break the glass but could ignite or deform the window frame, permitting the glass to fall out and again exposing the building to subsequent entry of flames.

The vulnerability of windows is closely related to their orientation and location. Since most windows are vertically oriented (skylights are an exception), this would cause exposure to the maximum level of radiation. One of possible sources of a very high level radiation is an adjacent structure that is involved in fire. Ground level windows are also exposed to combustible fuels that may be adjacent to a structure, including ornamental plants, decks, and stored materials. Also, if the structure has combustible siding, this represents another source of fire that can even extend to upper level windows.

In addition to orientation and location, windows have construction characteristics that make prescriptive recommendations impractical. These include glass resistance to heat and breakage, number of lights (single, double, triple glazing), the type of frames (fixed, casement, sliding, hung, etc), framing materials (wood, plastic, fiberglass, aluminum; and combinations of these), and installation (details, including that for replacement windows).

Development of the Test Protocol.

In preliminary tests, the exposure was 150 kW for 3 min and 150 kW to failure. The former exposure is considered the minimum that a window might receive from a small ornamental plant directly under the window and were conducted to see if the various frame materials would sustain

combustion and fail after removal of the flame. The latter exposure was conducted to determine the category of failure (glass or frame).

Materials.

Since there are so many potential combinations of frame material, frame type, and glass type/configuration, only a relatively few possibilities could be tested (Table 1). Commercially-available 2 x 3 ft (600 x 900 mm) window units were purchased from a local retailer. A full range of frame materials for single- or double-hung windows with double-pane glass was selected, several fixed windows, and those with single-pane glass.

Tests.

The windows were installed in a window-wall assembly that permitted rapid installation and removal of and designed to prevent edge penetration of fire at the margins. It includes two adjustable non-combustible side walls attached to a wall frame assembly, and a non-combustible floor and adjustable simulated soffit. The windows were subjected to fire performance testing by exposure to the 150 kW burner placed against the wall below the window. Several special tests were conducted with 300 kW flame-impingement exposure to determine the effects of an extreme exposure on glass and the effectiveness of screens as a “fire barrier.”

Results.

Failures were defined as loss of glass that could enable flame penetration, or penetration of fire through the frames. Glass failures occurred in 3 of 13 tests when exposed to 150 kW for 3 min (all occurred in less than 2 min). Of 6 exposed to 150 kW to failure, all failed in a range of 6 to 9 min (the three types of windows that failed in the 3-min exposure were not included in the test to failure). For resistance to flame impingement, *double-pane glass* is the clear choice, as can be seen from the data in Table 2. Tempered glass also appears to perform somewhat better than annealed, but the results are not definitive. The 300 kW flame impingement tests with metal screens in place (data not shown) indicated little, if any, protection to the glass.

Comments.

Since glass failure--not frame failure--was responsible for the termination of most the flame impingement tests, it was not possible to discern performance differences among the frame materials. However, other research has reported that radiant exposure can deform some double-hung vinyl window frames so that the glass falls out. The sensitive element in such a window is the horizontal interlock where the upper and lower sashes meet. In windows tested, and generally in larger vinyl windows, this interlock is aluminum reinforced (for protection against wind deformation), which may protect against this type of failure.

The marginal difference between annealed and tempered glass in the two exposure intensities should not be considered an endorsement for annealed glass, since tempered glass is expected to offer impact resistance to flying debris.

Although metal screens indicated little, if any, protection to the glass, previous studies have shown that they provide some shielding against radiant heat exposure. They would also be expected to protect the window somewhat from impact by flying debris.

Two areas not tested—radiant exposure and impact—will require protocol development and testing in the future to amend the Standard.

Conditions of acceptance.

The conditions of acceptance are more rigorous than the testing would support, since it was felt that windows must have the same exposure conditions (150 kW for 10 min) as do external walls in SFM-1. In support of these conditions, there were clear indications in the testing that window manufacturers should be able to make appropriate modifications to meet the provisions of the Standard.

Table 1. Windows selected for testing

Glass	Wood	Aluminum	Vinyl clad wood	Vinyl clad wood	Aluminum (aluminum-clad wood reinforced)	Fiberglass	Aluminum	Vinyl
Single pane (annealed)		H						
Single pane (tempered)		H						
Double pane (annealed)	H	H	H	H	H	H	F	F
Double pane (tempered)		H			H			

H = Single/double hung
F = Fixed

Table 2. Window construction and results

Frame Type	Frame material	Glass Type	150 kW failure (min) location***	300 kW failure (min) glass
Single/double hung	Aluminum-clad wood	Single-pane (annealed)	1:30 (g) 8:50 (f)	0:33
Single/double hung	Aluminum-clad wood	Single-pane (tempered)	8:15 (f)	1:15
Single/double hung	Vinyl (aluminum-reinf.) (Milgard)	Single-pane (annealed)	6:51 (g)	2:10
Single/double hung	Vinyl (aluminum-reinf.) (Milgard)	Double-pane (tempered)	6:00 (g)	2:45
Single/double hung	Vinyl (aluminum-reinf.) (JeldWen)	Double-pane (tempered)	6:00 (f)	2:58
Single/double hung	Aluminum-clad wood	Double-pane (annealed)	5:55 (f)	1:09
Single/double hung	Wood	Double-pane (annealed)	1:45 (g)	1:46
Single/double hung	Vinyl-clad wood	Double-pane (annealed)	1:45 (g)	1:05
Single/double hung	Aluminum-clad wood	Double-pane (tempered)	3:00**	3:07
Single/double hung	Aluminum	Double-pane (annealed)	3:00**	2:56
Single/double hung	Fiberglass	Double-pane (annealed)	3:00**	6:28
Fixed	Aluminum-clad wood	Double-pane (annealed)	3:00**	3:45
Fixed	Vinyl	Double-pane (annealed)	3:00**	1:20

* Time is the average of test replicates. If the failure location in replicate tests was different, both times are given.

** Tests of frame materials for sustained combustion. 150 kW flame exposure stopped at 3 min; no failure observed

*** Failure in glass (g) or frame (f)

URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

EAVES

STANDARD SFM-3

STATE FIRE MARSHAL

(b) **Application.** *The minimum design, construction and performance standards set forth herein for exterior wall eaves are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A*

(c) **Scope.** *This standard determines the performance of eaves of exterior walls of structures when exposed to direct flames.*

(d) **Referenced documents.**

1. *ASTM D4444. Standard Test Methods for Use and Calibration of Hand-Held Moisture Meters*
2. *California Building Code, Chapter 7A.*

(d) **Definitions**

1. **Eaves.** *A projecting edge of a roof that extends beyond the supporting wall.*
2. **Soffitt.** *The enclosed underside of any exterior overhanging section of a roof eave.*

(e) **Equipment**

1. **Burner.** *A 4 x 39 in. (100 x 1000 mm) propane diffusion burner shall be used.*
2. **Infrared temperature analyzer** (optional). *Intended for monitoring the temperature change of the inside of the eaves.*
3. **Moisture meter.** *For measurement of moisture content of framing (see ASTM D4444).*

(f) **Materials**

1. **Framing.** The materials used shall be representative of the grades that would be typical of eave construction and installed in the eaves subassembly as per accepted construction practices.

2. **Soffitt.** Material selected for the test.

(g) Test system preparation (Figure 1)

1. **Eaves fabrication.** The assembly shall be constructed to fit into a 4-ft- (1.2-m-) wide space in the wall module. Normal roof framing, joints in soffit material, and other typical features present in the constructed assembly shall be present in the test specimen.

2. **Wall Module.** The module shall be designed to permit rapid installation and removal of eave assemblies and have two adjustable non-combustible sidewalls.

3. **Eaves assembly.** Fit the eave assembly into the wall module so that the lowest point of the assembly is 82 in. (2.1 m) from the top of the burner.

4. **Moisture content.** Measure the moisture content of the wooden members of the assembly using a moisture meter (D4444).

5. **Sealing.** Seal the edges and ends with ceramic wool or comparable material to prevent flame penetration in these locations of the eave assembly.

6. **Finish.** The eaves shall be finished in a manner appropriate for exterior exposure as per accepted construction practices.

(h) Conduct of Tests.

1. **Airflow.** The wall test shall be conducted under conditions of ambient airflow.

2. **Number of tests.** Conduct the tests on three replicate eaves assemblies .

3. **Burner output verification.** Without the eaves assembly in place, adjust the burner for 300 ± 15 kW output. Extinguish the burner.

4. **Burner configuration.** Center the burner with respect to the width of the eaves-wall assembly and 0.75 in. (20 mm) from the wall. The distance from the floor to the top of the burner shall be 12 in. (300 mm).

5. **Procedure**

i) Ignite the burner, controlling for a constant 300 ± 15 kW output.

ii) Continue the exposure until flame penetration of the eaves occurs or for a 10-min period.

iii) If penetration does not occur, continue observation for an additional 30 min or until all combustion has ceased. An infrared thermometer has been found to be useful to detect the increase of temperature on the back side of the eaves and as an aid to identify the areas of potential combustion.

6. **Observations.** Note the time, location, and nature of flame penetration.

(i) **Report.** The report shall include a description of the eaves material, details of the construction of the eaves, moisture content of the framing, and point of flame penetration. Provide details on the time and reasons for early termination of the test.

(j) **Conditions of Acceptance.** Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.

1. Absence of flame penetration of the eaves at any time.
2. Absence of structural failure of the eaves subassembly at any time.
3. Absence of sustained combustion of any kind at the conclusion of the 40-min test.

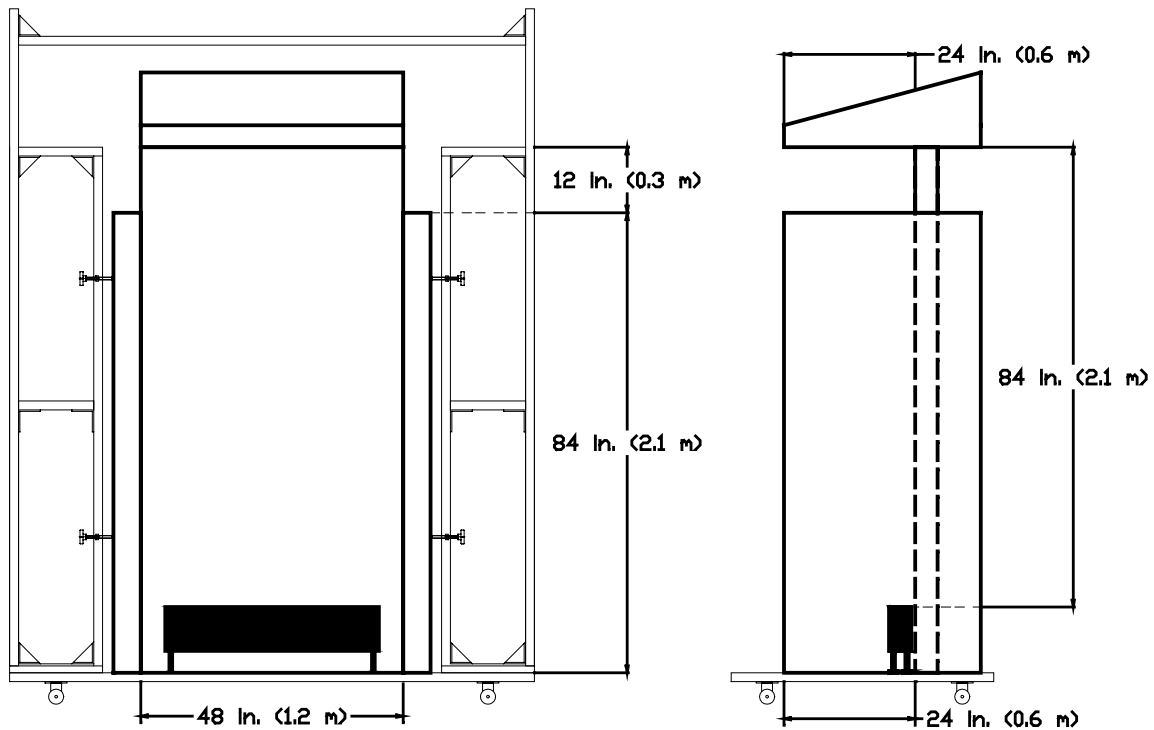


Figure 4. Eaves-Wall Test Assembly

COMMENTARY: EAVES

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to “certify” materials and/or assemblies, but to provide guidance in the development of the test protocols and for the “conditions of acceptance.” Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.

Eaves have three concerns of interest:

1. Ignition from combustible siding or other combustibles near the base of a structure, and penetration through the soffitt, or unboxed or boxed eaves, or seams in any of these assemblies.
2. Increased risk of fire penetration into the attic or wall assembly at the roof-to-wall interface.
3. Any vents associated with eaves.

Development of the Test Protocol.

Since flaming combustion from ornamental plants (or equivalent combustibles) or from exterior wall cladding is the most probable source of fire exposure, tests were run to simulate exposure from medium-size plants and cladding. In preliminary tests, the decision was to use a 600-kW line burner output until burn-through was indicated.

Tests.

Materials. Two boxed-in eave configurations were tested: a soffitt consisting of nominal 1 x 4 tongue-and-groove boards, and 6 mm (0.25 in.) plywood. The boards were a clear grade of Douglas-fir, attached by blind nailing through the tongue of each board into the roof rafter. The plywood was an AC grade, with the “A” face exposed to the flame.

Assemblies. The channelized wall assembly used for the wall and window tests was also used in for these tests, where all vertical members consisted of gypsum wallboard. The soffitted eave assembly was attached to the wall assembly. The outside edges of the soffitt materials, at the connections to the wall assembly at the horizontal top plates, were protected with strips of ceramic wool to prevent flame penetration at joints.

Test procedure. For each test a single layer of newspaper was placed directly on top of the soffitt material on the inside of the eave assembly to use for visual detection of burn-through.

Results. The two replications of the plywood soffitt samples had burn-through at 1:30 and 2:00 min. Failure occurred at an open knot on the unexposed face of replication #1, and through a core gap in replication #2. In both cases, failure occurred within 150 mm (6 in.) of the back wall. The two replications of the Douglas-fir tongue-and-groove soffitt failed at approximately 8:00 and 6:00 min. As was the case with the plywood, failure occurred near the back wall at the first or second joint from the wall.

Comments. Although the tests were run at 600 kW, observations during the testing suggested that 300 kW for 10 min would be a reasonable exposure. The length of time is consistent with the 10-min exterior wall and window Standards (SFM-1 and SFM-2). The 300 kW level is double that for the latter standards and is reasonable to account for the heat release of ignitable siding that was noted in preliminary testing of cladding. The limited testing done to date on soffitt materials support observations made in tests of other materials: protection of joints is critical, and defects within the field of a material that reduce its effective thickness will adversely affect performance. With combustible soffitt materials, joints or product variability would likely be the weak link in the assembly. For most non-combustible soffitt materials, such as a fiber-cement product, joints between panels will be the most likely point of failure. Although not directly indicated by the results of these tests, providing adequate fire barrier protection at the eave to exterior wall interface is critical, and should be incorporated in test procedures as well as in “best practices.” Vulnerability of vents located in the soffitt area must be addressed in a future standard.

Conditions of Acceptance. Based on the tests, the acceptance criteria listed in Standard SFM-3 were considered appropriate

URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

ROOF ASSEMBLIES STANDARD SFM-4

STATE FIRE MARSHAL

(e) **Application.** *The minimum design, construction and performance standards set forth herein for roof coverings and assemblies are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A*

(b) **Scope.** *This standard determines the performance of roof coverings and assemblies when exposed to brands. The burning brand exposure test is intended to determine the degradation modes of roof covering materials or assemblies when exposed to a burning brand on the upper surface. In addition to this standard, all assemblies must comply with other tests in E108 or equivalent standard.*

(c) Referenced documents.

1. ASTM D 4933 Guide for moisture conditioning of wood and wood-based materials
2. ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings
3. California Building Code, Chapter 7A

(d) Definitions.

1. **Roof Covering.** *Roofing material that is directly exposed to the weather.*
2. **Roof Assembly.** *All materials in the roof system, including roof covering, sheathing, building paper or felt (water resistive barrier), support joists, and any other materials used between the roof joists and roof covering.*

(e) Equipment.

1. **Anemometer.** *Device for measuring airflow across the deck.*
2. **Infrared temperature analyzer** (optional). *Intended for monitoring the temperature change on the bottom surface of the sheathing material.*

(f) Materials.

1. *Material tested must be representative of commercially available products*
2. *All materials are to be conditioned to equilibrium to 6% EMC conditions prior to testing as specified in ASTM D4933.*

(g) Test system preparation

1. Apparatus. The apparatus shall be constructed as described in Section 4.1, ASTM E-108. The 60-in. (1.5 m) framework spacing specified for the burning brand test shall be used (Figure 1).

2. Test Deck. The test deck shall be framed as indicated in Figure 4(a) (Class "A" Roof), referenced in Section 5.1.1, ASTM E-108. Panel joints in solid sheathing shall be configured as indicated in this figure.

- i) Sheathing and other materials included in the test deck can be any permitted by the manufacturer of the roof covering.
- ii) Framing lumber shall be from species available in a structural light-framing grade. The joists shall be conditioned to 6% EMC as specified in ASTM D 4933.
- iii) The roof covering material shall be installed in accordance with manufacturer installation instructions.
- iv) Any materials beneath the roof covering that are used to obtain a Class "A" rating must be reported, including labels on the materials that relate to performance or composition.
- v) Panelized barrier materials used to obtain the fire rated assembly must include a joint that is offset from the solid sheathing joint by 4 in. (100 mm). The joint can be either parallel or perpendicular to the airflow direction.
- vi) The slope of the prepared test decks shall be as specified in Section 6.7 of ASTM E-108.

3. Measurement of temperature. At a minimum, thermocouples shall be placed directly on top of the roof sheathing, and under the felt and other components in the roof assembly, as shown in Figure 2. It is advantageous to use infrared imaging to monitor temperature of the exposed side of the roof sheathing.

(h) Conduct of Tests

1. Number of tests. Conduct the test on three replicate assemblies.

2. Procedure. Adhere to ASTM E108 "Standard Test Methods for Fire Tests of Roof Coverings" (burning brand test, "A" brand) with regard to the construction and placement of the "A" brand, with the following exceptions:

- i) The air velocity shall be calibrated using the 60-in. (1.5 m) framework spacing.
- ii) The ignition procedure of the "A" brands shall be as specified in Section 9.4 of ASTM E 108, except the ignition sequence shall be:
 - (1) Each 12- x 12-in. (300- x 300-mm) face for 30 s
 - (2) Each 2.25- x 12-in. (57- x 300-mm) edge for 30 s
- iii) Brand position. Place the brand on the roof as specified in E108.
- iv) Continue the exposure until flaming or glowing combustion of the roof covering and assembly ceases, burn-through to the underside of the deck occurs, or 90 min elapses.

3. Observations. Note physical changes of the roof deck and assembly, including location of flaming and glowing combustion on the exposed upper and lower surfaces, and loss of material (i.e., flaming drops of particles falling from

the underside of the deck). It is desirable to capture the entire test for both the upper and lower surfaces of the roof deck with a video recorder to allow review of the details of performance.

(i). Report. *The report shall include description of the roof covering material and construction materials and installation details used in the roof assembly and the time of any observation of degradation.*

(j). Conditions of Acceptance. *Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.*

1. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 90-min observation period.

2. Absence of burn-through to the underside of the roof deck, or development of holes exceeding 1 sq. in. (650 mm²) resulting from combustion.

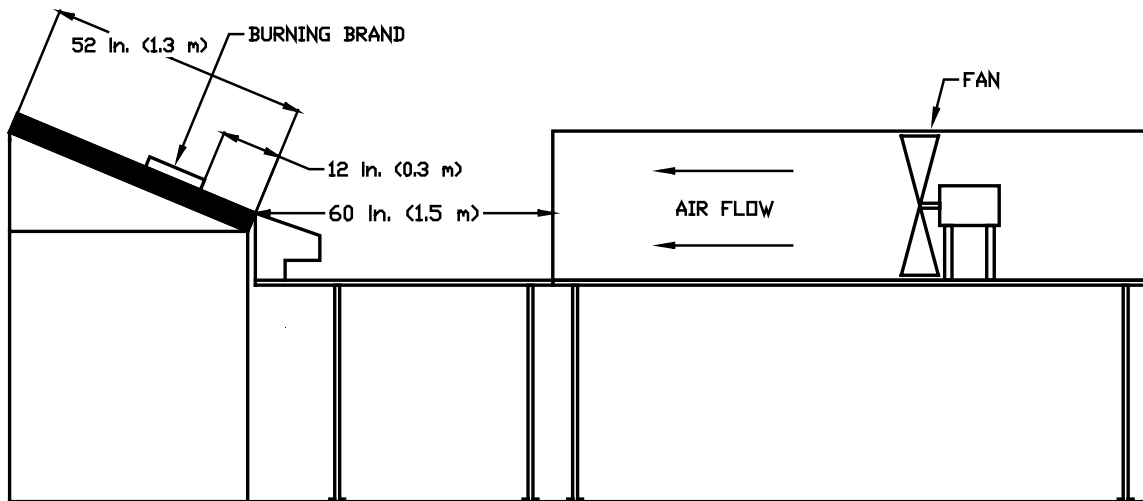


Figure 5. Roof Test Assembly ("A" Brand)

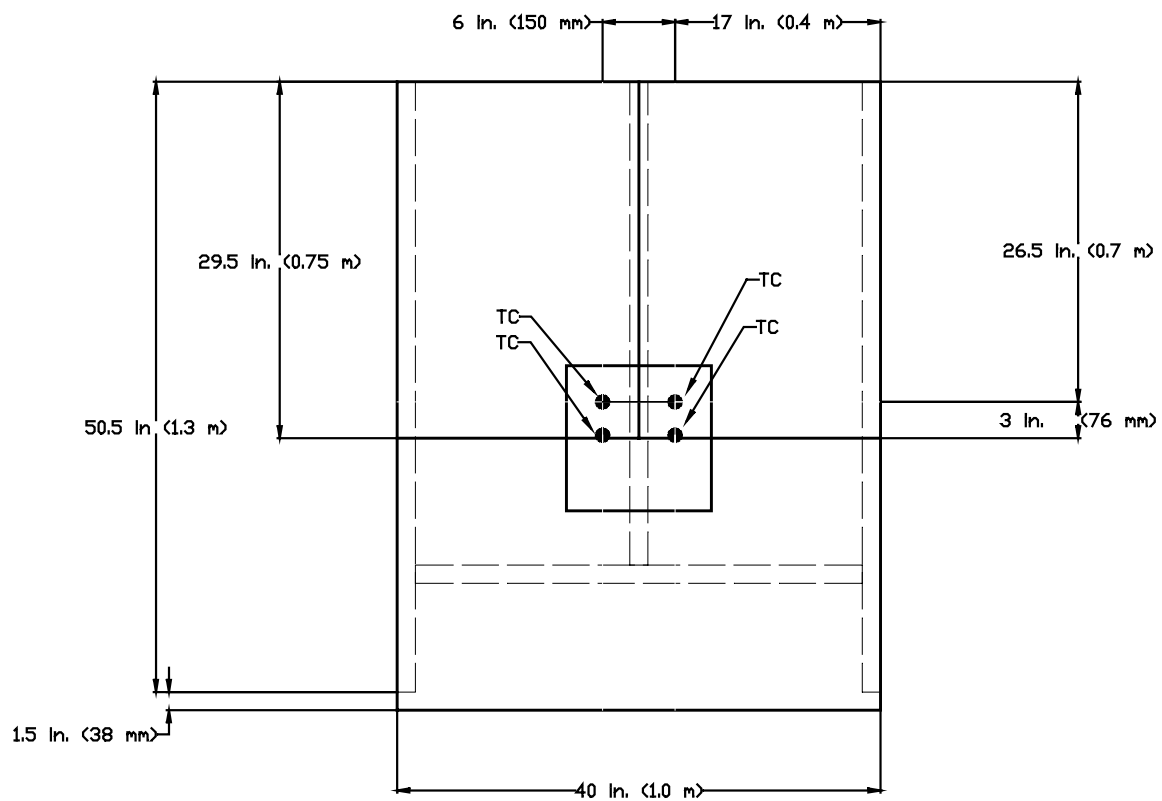


Figure 6. Roof Test Assembly (thermocouple placement)

COMMENTARY: ROOF ASSEMBLIES

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to “certify” materials and/or assemblies, but to provide guidance in the development of the test protocols and for the “conditions of acceptance.” Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire.

It is well-known that many structures are severely damaged or destroyed in UWI fires because of roofing materials. Roof coverings are already subject to fire regulations that require testing under ASTM E108 or equivalent standards, which represent the only existing performance standards applicable to UWI fire. However, roofs become involved in fire for many reasons other than the roof coverings. For example, the eaves are very vulnerable because of combustible roof edges that are adjacent to rain gutters and the entrapment of burning brands in gutters that contain flammable debris. There are also certain roof coverings and/or designs that permit entry of brands because of unstopped openings or lifting of the coverings from high winds. Complex roof designs often have recesses where combustible debris can accumulate and in which brands can land, and may have combustible vertical surfaces associated with these designs. Most of these latter issues can be addressed by prescriptive measures, or building designs or practices, and it would be very difficult to design meaningful performance tests. Roof coverings have a number of required tests in the current standards that must be passed for ratings. Since the Roof Assembly (SFM-4) is for VHFHZ, the most appropriate rating is “Class A.” Class A refers to a 2 kg burning brand, 1 x 1 ft (300 x 300 mm) constructed of a lattice of 36 strips of wood, 0.75 x 0.75 in. (19 x 19 mm) in cross-section.

Roof assembly. E108 is a test method for roof coverings that can be applied to roof assemblies, which include the materials below the covering. The assembly is the same as described in ASTM E108, except that any panelized barrier materials used to obtain the fire rated assembly must include a joint that is offset from the solid sheathing joint by 4 in. (100 mm).

Development of the Test Protocol. The protocol includes a roof assembly as described above and exposed to the “A” brand test. In addition, all assemblies must comply with other tests in ASTM E108 or equivalent standard.

Air velocity. ASTM E108 specifies 12-mph airspeed, however, there have been suggestions that this level of airflow is not representative of UWI “fire weather” conditions that often have winds

up to 60 mph. In preliminary tests, it was found that a wind speed of 20 mph was less severe than 12 mph, apparently due to more rapid consumption of the burning brand. Higher velocities simply cause more rapid consumption of the brand and cool the brand area from the higher forced convection. Also, higher airflow can lead to greater losses of fragments of the burning brand as well as dislodging roof coverings. On the other hand, airflow lower than 12 mph supplied sufficient oxygen for vigorous combustion of the brand without the cooling effect. However, at very low airflow, the effect of the brand is more limited because of reduced oxygen.

Brand size. Roof covering ratings are partially based on their performance as affected by the brand size. Since it was reasonable that a larger brand than “A” would be a more rigorous test, “AA” brands were constructed having the same footprint as an “A” brand, but with thicker material to double the mass to 4 kg. When tests were run using an ASTM E108 configuration, the “AA” brands gave virtually the same results as “A” brands, therefore, using the “A” brand was considered a reasonable UWI fire test method.

Tests

In view of the preliminary testing, it initially appeared unnecessary to recommend testing beyond that in ASTM E108. However, it was decided to run tests with different combinations of common materials that are used for class A roof covering certification to determine if the assembly construction (vs covering alone) had any effect on rating. In our testing, it was difficult to determine if and where smoldering combustion occurred or where there was significant temperature build-up during the test. In the E108 test, 8 thermocouples are installed in prescribed places, but this represents a very small sampling of the under-deck area. Since we were using an infrared camera in our wall testing, we attempted to use it for roofs and found that it provided very useful temperature patterns to help define the combustion condition. The roof coverings were built into roof deck assemblies according to manufacturers' specifications. Where fire barrier and sheathing materials were not precisely specified by a manufacturer, we made a variety of test decks with components in common use. The test protocol involved placement of a burning "Class A" brand on the test roof deck and exposing it to a 12 mph wind source. The test was terminated when glowing combustion or smoldering stopped, or when the test deck failed due to flame penetration to the underside of the roof deck.

Materials. Six commercially-available “A”-rated roof coverings (asphalt composition, fire-retardant-treated wood shakes, fiber-cement, concrete tile, aluminum, and fiberglass-reinforced resin) were purchased from retail outlets. CDX plywood and oriented strandboard (OSB), which has largely displaced plywood in roof sheathing, were used as roof decking in matched tests with different roof coverings (Table 1). For selected assemblies, variations were tested with the fire barrier material. All roof decks were constructed according to ASTM E-108, with lapped 30-pound felt under the roof covering. Sheathing was installed with joints, as required in the standard, for both OSB and plywood.

Results. Note that in Table 1, there are several levels of comparison for roof assemblies:

1. Cap sheet 1 vs 2 (both 72 lb, but different manufacturers).
2. CDX plywood vs OSB for the following:
 - FRT shakes with DensDeck®
 - FRT shakes with Cap sheet 2
 - Hardie-Shake wood fiber-cement with no fire barrier
 - Owens-Corning resin-glass fiber with no fire barrier
3. OSB/Plywood with covering that passed with no fire barrier for:
 - Concrete tile (OSB)
 - Asphalt composition (“30-yr”)(OSB)
 - Wood fiber-cement (Plywood)
 - Resin-glass fiber (Plywood)
4. Fire barriers: Cap sheet vs DensDeck®
 - FRT shakes/OSB
 - FRT shakes/Plywood

Also note the 70-min flame-through for FRT shake with Plywood and Cap sheet 2. This long period before flame-through was the basis of extending the total test time for the final standard to 90 min.

Comments. The fact that some Class “A” roofing passed with plywood, but failed with OSB, showed that the choice of sheathing material, though not specified by some roofing manufacturers, may be critical to the fire performance of the roof. Also, some manufacturers offer roof coverings as “Class A” rated, with no indication of additional assembly components to achieve this performance. Presumably, any assembly using such a “Class A” covering would pass a “Class A” roof test. Other manufacturers specify additional assembly components and installation details, such as inclusion of a flame barrier of 72-lb capsheet, which enables the roof assembly to pass the E-108 “Class A” fire test. The joint in DensDeck®, which we considered representative of actual roof installation, was where failure occurred when OSB sheathing was used. In the case of the assemblies with 72-lb capsheet (roll roofing), normal installation requires an overlap at the joints, so lack of detail for this type of assembly in E-108 was not an issue.

Although not within the scope of the supporting research, some preliminary tests were made with “C” brands (approx. 9 g in mass) and velocity over 20 mph to reflect a more realistic scenario for the brands that occur during firestorms. This scenario should be included in future tests on valleys and crevices of roofing. An additional issue for future research on roofs is the possible ignition at the edges adjacent to gutters, where accumulated debris could pose a hazard to the roof.

Conditions of acceptance. The major deviation from the “A” brand test in E108 is the requirement of a 90-min period for the test. This is important since smoldering combustion can persist in roof assemblies for a considerable time, and 90 min was judged adequate for assuring that such combustion has terminated.

Table 1. Roof deck construction & fire test results

Product	Covering type	Sheathing ^a	Fire barrier ^b	Result	Test duration ^c (min)
Monier Lifetile "Country Shake"	Concrete tile	OSB	--	Pass	15
James Hardie Bldg. Prod. "Hardislate"	Fiber-cement	CDX	--	Pass	15
Elk Premium Roofing "Prestique I"	Asphalt Composition	OSB	--	Pass	20
Classic Products "Rustic Shingle"	Aluminum	OSB	Cap sheet 2	Pass	23
Owens Corning "Mira Vista Shake"	Resin-glass fiber composite	CDX	--	Pass	23
Cedar-Plus Western Redcedar shakes	FRT wood	CDX	DensDeck®	Pass	58
Cedar-Plus Western Redcedar shakes	FRT wood	CDX	Cap sheet 2	Flame-through	70
Cedar-Plus Western Redcedar shakes	FRT wood	OSB	Cap sheet 1	Flame-through	44
Cedar-Plus Western Redcedar shakes	FRT wood	OSB	DensDeck®	Flame-through	38
Cedar-Plus Western Redcedar shakes	FRT wood	OSB	Cap sheet 2	Flame-through	37
Owens Corning "Mira Vista Shake"	Resin-glass fiber composite	OSB	--	Flame-through	20
James Hardie Bldg. Prod. "Hardislate"	Fiber-cement	OSB	--	Flame-through	16
Eternit "Stonit Continental Slates"	Fiber-cement	OSB	--	Flame-through	14

^a "OSB" = oriented strandboard; "CDX" = plywood (CDX grade)

^b Cap sheet 1 & 2 = 72 lb cap sheet (roll roofing) from two different manufacturers;

DensDeck® is a "nonstructural glass mat-faced...gypsum core panel" from Georgia-Pacific Corp.

^c For those with "pass," the "test duration" is the time at which all combustion ceased

URBAN WILDLAND INTERFACE BUILDING TEST STANDARDS

DECKS AND OTHER HORIZONTAL ANCILLARY STRUCTURES STANDARD SFM-5

STATE FIRE MARSHAL

(f) **Application.** *The minimum design, construction and performance standards set forth herein for unloaded decks are those deemed necessary to establish conformance to the provisions of these regulations. Materials and assemblies that meet the performance criteria of this standard are acceptable for use in Very High Fire Hazard Zones as defined in California Building Code, Chapter 7A.*

(b) **Scope.** *This standard determines the performance of decks (or other horizontal ancillary structures in close proximity to primary structures) when exposed to direct flames and brands. The under-deck flame exposure test is intended to determine the heat release rate (HRR) and degradation modes of deck or other horizontal boards when exposed to a burner flame simulating combustibles beneath a deck. The burning brand exposure test is intended to determine the degradation modes of deck or other horizontal boards when exposed to a burning brand on the upper surface.*

(c) Referenced document

1. ASTM D4933. Guide for moisture conditioning of wood and wood-based materials
2. ASTM E108. Standard Test Methods for Fire Tests of Roof Coverings
3. California Building Code, Chapter 7A

(d) Definitions.

1. **Deck boards.** *Horizontal members that constitute the exposed surface of the ancillary structure.*
2. **Heat release rate.** *The net rate of energy release as measured by oxygen depletion calorimetry*

(e) Test Assembly.

1. **Size.** *The overall size of the test deck shall be 2 x 2 ft (610 x 610 mm) unless width variation of deck boards requires an increase in overall deck width (i.e., the direction of joists) in order to meet the overall dimensions. The length of individual deck boards shall be 2 ft (610 mm).*
2. **Joists.** *The deck is supported by two sets of 2 x 6 Douglas-fir joists, 28 in. (710 mm) long, and constructed with a 16-in. (406 mm) center-to-center*

spacing. The joists shall be conditioned to 6% equilibrium moisture content as per ASTM D4933. A comparable species that may be more commonly used for structural framing of decks in a given region can be substituted for Douglas-fir.

3. Deck board spacing and fastening. Edge-to-edge spacing is 3/16 in. (5 mm), with boards attached to the joists with 2-in. (50 mm) deck screws inserted into deck boards spaced 1.5 in. (38 mm) from the front and back edges of the deck boards. The front deck board shall be flush with the ends of the joists, and the rear deck board shall overhang the end of the joists by 1 in. (25 mm).

- i) Boards manufactured for tongue and groove edge connections are to be spaced as per the manufacturer's recommendation.
- ii) Alternate fastening schedules can be used if specified by the deck board manufacturer
- iii) If 2 x 6 deck boards are used, a total of 5 boards shall be used for each deck. Changing the board width could change the number of deck boards.

(f) Materials.

1. All deck board materials are to have cross-sectional dimensions equivalent to use in service.
2. Material tested must be representative of commercially available products
3. If solid wood deck boards are used, the species or lumber group shall be identified.
4. If the material is "plastic lumber" or other composites, the type and amounts of the plastic(s) and the wood-plastic ratio shall be determined.
5. All materials are to be conditioned to equilibrium to 6% EMC conditions prior to testing as specified in ASTM D4933.

PART A. Under-flame test

(a) Equipment

- 1. Burner.** A 12 x 12 in. (300 x 300 mm) sand burner shall be used to provide an output of 80 ± 4 kW using a regulated propane gas source. Burner output can be determined from HRR or calculated from propane flow rate, temperature, and pressure.
- 2. Oxygen depletion calorimeter.** The system includes a hood, associated ducting, and instrumentation to provide HRR data by oxygen depletion calorimetry.

(b) Test system preparation (Figure 1)

- 1. Deck support assembly.** Assembly that holds the test deck over the burner.
- 2. Baffle panels and joist support.** Horizontal metal plates to support the deck joists along their full length, and also to confine burner flames to the underside of the deck boards located between the support joists.
- 3. Back wall.** Ceramic fiber board or another noncombustible panel product for the back wall material. Total height of the back wall is 8 ft (2.4 m).
- 4. Ledger board.** A 4-ft (1.2-m) long simulated 2 x 6 ledger board shall be constructed of layers of ceramic fiber board (or other noncombustible panel product) and attached to the wall at a height slightly below the overhang of the rear deck board of the test deck

(c) Conduct of Tests.

- 1. Airflow.** The test is conducted under conditions of ambient airflow.
- 2. Number of tests.** Conduct the test on three replicate assemblies
- 3. Burner output verification.** Without a deck in the apparatus, set the output of the burner to 80 ± 4 kW. Conduct a verification run of 3 min to assure the heat release rate, then turn off the burner.
- 4. Measurement of heat release rate.** HRR is measured during the tests with a properly calibrated oxygen depletion calorimeter. Since HRR is typically a post-test analysis, this criterion for Acceptance may be determined at the end of the test.
- 5. Burner configuration.** Center the burner directly under the middle deck board, midway between the joists. The distance from the top of the burner to the bottom of the deck boards shall be 27 in. (690 mm)
- 6. Procedure.**
 - i) Ignite the burner, controlling for a constant 80 ± 4 kW output.
 - ii) Continue the exposure for a 3 min period, Extinguish the burner.
 - iii) Continue observation for an additional 40 min or until all combustion has ceased. The test shall be terminated immediately if flaming combustion accelerates uncontrollably (runaway combustion) or structural failure of any deck board occurs.
- 7. Observations.** Note physical changes of the deck boards during the test, including structural failure of any deck board, location of flaming and glowing ignition, and loss of material (i.e, flaming drops of particles falling from the deck). It is desirable to capture the entire test with a video recorder to allow review the details of performance.

(d) Report. The report shall include a description of the deck board material and the time of any degradation (peak heat release rate, structural failure, flaming drops or particles falling from the deck) during the test.

(e) Conditions of Acceptance. Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.

1. *Peak heat release rate of less than or equal to 25 kW/ft² (2.3 kW/m²)*
2. *Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 40-min observation period.*
3. *Absence of structural failure of any deck board.*
4. *Absence of falling particles that are still burning when reaching the burner or floor.*

PART B. Burning brand exposure

(a) Equipment

1. **Wind tunnel.** *The wind tunnel shall have the capability of providing 12 mph (5.4 m/s) airflow over the deck assembly*
2. **Anemometer.** *Device for measuring airflow across the deck.*
3. **Burner.** *Gas-fueled burner for brand ignition.*

(b) Test system preparation. *(Figure 2). The ASTM E108 "A" brand roof test apparatus is to be used, with the following modifications:*

1. **Deck support.** *The deck shall be supported horizontally with the center 60 in. (150 mm) from the front opening of the wind tunnel and the joists parallel to the airflow and resting on two transverse metal supports. The top surfaces of these supports, no more than 3 in. (75 mm) wide, are at the same height as the floor of the wind tunnel.*
2. **Fragments.** *Burning fragments shall be free to fall to the floor of the room.*

(c) Conduct of Tests

1. **Number of tests.** *Conduct the test on three replicate assemblies*
2. **Procedure.** *Adhere to ASTM E108 "Standard Test Methods for Fire Tests of Roof Coverings" (burning brand test, "A" brand), with apparatus modified as described above in "Test system preparation" and the following procedure:*
 - i) *The air velocity shall be calibrated using the 60-in. (1.5-m) framework spacing, with the deck positioned 60 in. (1.5 m) from the front opening of the wind tunnel. All other measurement details shall be followed as specified in sections 4.4.2, 4.4.3, and 4.4.4 of ASTM E 108. Although ASTM E 108 specifies calibration to be conducted with the 33-in. (840-mm) framework*

spacing used for the intermittent flame test set up, tests have shown that at the nominal 12 mph setting, there was not difference in measured velocity between the 33- and 60-in. framework spacing.

ii) Ignite the "A" brands as specified in Section 9.4 of ASTM E 108, with the exception of the ignition sequence:

(1) Each 12- x 12-in. (300- x 300-mm) face for 30 s

(2) Each 2.25- x 12-in. (57- x 300-mm) edge for 30 s

iii) Center the burning brand laterally on the deck with the front edge 2.5 in. (64 mm) from the entering air edge of the deck.

iv) Continue the exposure for a 40-min period or until all combustion of the deck boards ceases or a board collapses.

v) Heat Release Rate is not monitored because of the impracticability with the specified airflow.

3. Observations. Note physical changes of the deck boards during the test, including deformation from the horizontal plane, location of flaming and glowing combustion, and loss of material (i.e, flaming drops of particles falling from the deck). It is desirable to capture the entire test with a video recorder to allow review of the details of performance.

(d). Report. The report shall include description of the deck board material, and the time of any degradation (accelerated combustion, board collapse, flaming drops or particles falling from the deck).

(e). Conditions of Acceptance. Should one of the three replicates fail to meet the Conditions of Acceptance, three additional tests may be run. All of the additional tests must meet the Conditions of Acceptance.

1. Absence of sustained flaming or glowing combustion of any kind at the conclusion of the 40-min observation period.

2. Absence of structural failure of any deck board. 3. Absence of falling particles that are still burning when reaching the burner or floor.

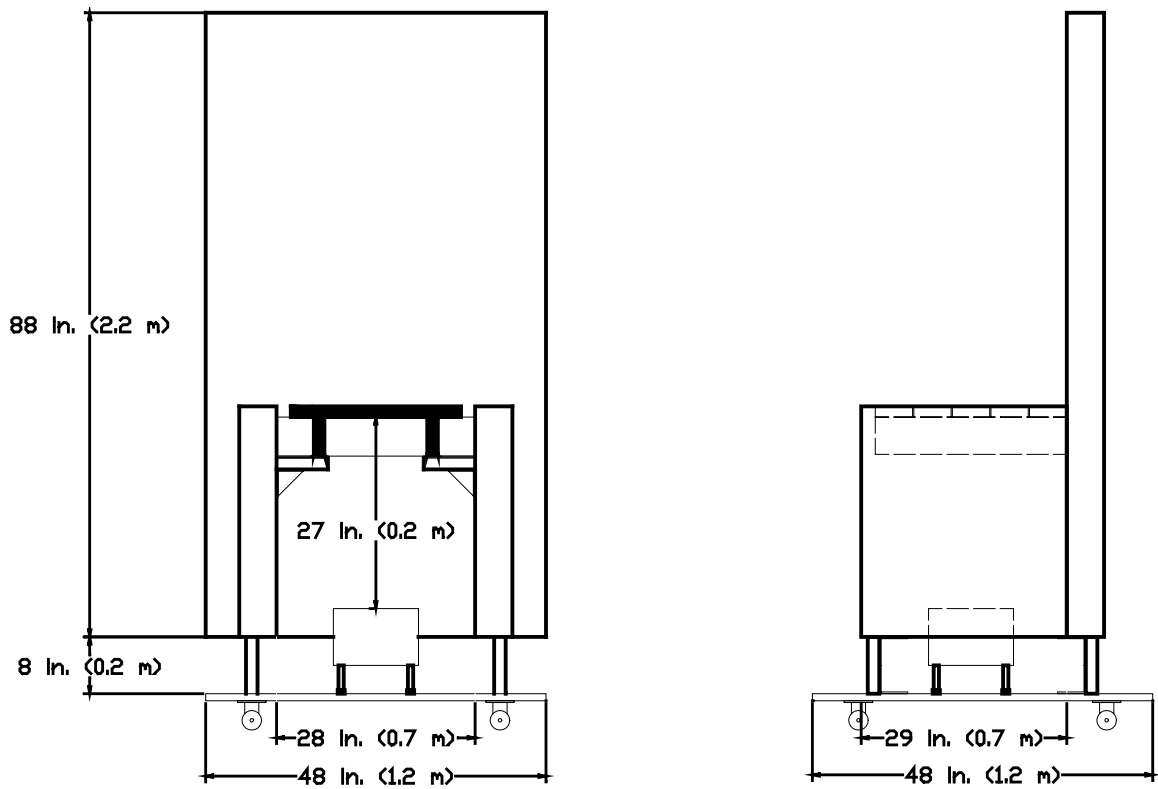


Figure 7. Deck Test Assembly (Under-flame)

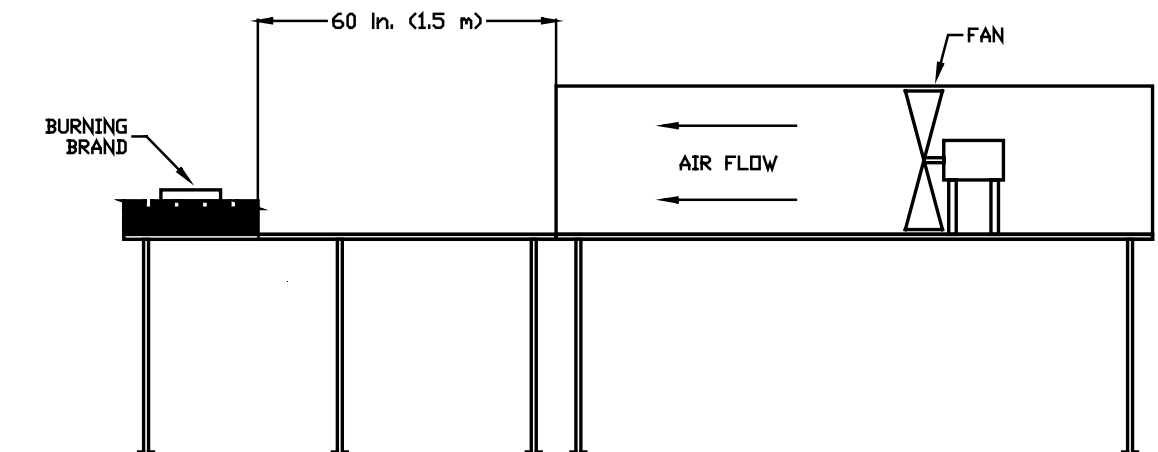


Figure 8. Deck Test Assembly (Burning-Brand)

COMMENTARY: DECKING

Purpose. This Commentary is to provide the background and rationale for the Standard. The work that led to this Standard was funded by the California Office of Emergency Services through the Office of the State Fire Marshal, and was provided as FEMA mitigation funds following the 1993 Southern California firestorm. Under the administration of OSFM, the University of California Forest Products Laboratory (UCFPL) developed fire test protocols for Urban-Wildland Interface (UWI) fire in consultation with fire researchers throughout the world and with fire authorities in California.

The research by UCFPL started in 1995; at the completion, after about four years, the work was reviewed by a committee of California fire authorities who prepared a report intended to lead to model building codes. However, the movement to code was delayed until 2004, when the California Legislature (through AB1216) directed OSFM to complete the code work by 1 January 2005. Under the administration of OSFM, the test protocols developed by UCFPL were written into Standards language.

Included in the Commentary are explanations of the development of test protocols and results from the preliminary tests at UCFPL. The tests were not intended to “certify” materials and/or assemblies, but to provide guidance in the development of the test protocols and for the “conditions of acceptance.” Also included are discussions of issues that were not addressed in the protocols, but which should be explored to amend the Standards to better address UWI fire issues.

Issues in UWI fire. The major concern about the ignition of decking is the hazard that it presents to the habitable structure. For example, most decks, porches, patios, and landings are directly adjacent (and usually attached) to the structure. Also, decks in particular tend to be above slopes having hazardous vegetation.

Most decking is configured so that it is threatened by two potential sources of ignition: brands and under-flames, with the following scenario:

1. A brand lands on a deck, causing glowing combustion at the opening between boards, and then to flaming combustion. The flames impinge on a sliding door, breaking the glass, and permitting penetration into the structure, or the flames impinge on combustible siding, causing penetration through the siding or at some other vulnerable point.
2. A brand is blown under a deck and on combustible material. The material ignites and the decking goes into flaming combustion. The flames impinge on a sliding door, breaking the glass, and permitting penetration into the structure, the flames impinge on combustible siding, causing penetration through the siding or at some other vulnerable point. Alternatively, the initial ignition could have been flame contact of the combustibles by a surface fire, but the outcome (penetration through a sliding door, siding combustion, etc.) would be the same.

In both scenarios, the outcome is the same—the deck goes into flaming combustion and the fire penetrates the structure. Decks can also present a hazard to other structures from flaming debris (brands) developed from the fire. Another often-unrecognized hazard is the loss of mechanical integrity of the deck boards after combustion that can present a hazard to anyone walking on the deck.

Deck assembly. A key decision was the construction and size of the deck. After under-fire testing various sizes from “pallet size” about 4 x 4 ft (1.2 x 1.2 m), it was found that the minimum size

for reproducibility was 2 x 2 ft (610 x 610 mm), with 2 x 6 joists spaced 16-in. (406-mm) on center (a common joist spacing for decks). Deck board spacing was 3/16 in. (5 mm). There is a key relationship between deck and burner size, in that the burner must be small enough to not impact the deck edges. The 12- x 12-in. (300- x 300-mm) burner concentrated its direct energy in an area slightly larger than the burner size. For combustible materials, there is also horizontal flamespread on the underside that is largely confined to the space between the joists.

Development of the Test Protocol. Since there are two scenarios for ignition, two tests were developed: (1) decking under-flame and (2) top-deck flaming brand. The “under-flame” deck assembly was supported over a 12- x 12-in. (300- x 300-mm) propane burner, and abutted to a 1.8-m gypsum board wall. The under-decking test was modeled after Babrauskas (1995) and Lee (1985) by using an 80-kW fire (equivalent to about 1 kg of paper trash). The under-flame test included a measurement of heat release rate to determine if that would be a useful criterion for determining accelerated combustion. In order to have impingement of the flame tip on the underside of the deck boards a spacing of 27 in. (690 mm) from top of burner to bottom of decking was chosen. Preliminary tests were conducted to determine the length of time of exposure to flames, and a 3-min exposure was consistent for the 1-kg paper scenario, and produced the best sensitivity in decking performance. The top-deck flaming brand test was modeled after a similar brand test for roofs as described in ASTM E108, also using 12 mph airflow.

Tests

Materials. The deck tests included 15 commercial deckboard materials (wood, wood/plastic, and all-plastic) that were chosen to be representative of the range of more than 20 products available on the market in early 2001. Selection of products was based on material composition and cross-section form. The deck materials were purchased from retail sources between March and May 2001. The boards were cut into 610 mm (2 ft) lengths, and five pieces, taken from different full-length boards to minimize effects of any board-to-board variability, were used to make each test deck.

Under-flame tests were conducted on the deck materials shown in Table 1. Since many decks in California are constructed of nominal 2-in. (38-mm) deckheart-grade redwood, this material served as a reference in an approach similar to that of ASTM E 84, Standard test method for surface burning characteristics of building materials. Where E 84 uses red oak conditioned to 12% moisture content (MC), the deck materials were conditioned to 6% MC in order to simulate the very low equilibrium MC conditions of fire weather. Since a number of new plastic and “plastic-lumber” products were appearing on the market, representative materials were acquired from retail outlets. Each of these was analyzed (Table 1) since variation in composition could affect their performance. Based on the results of the under-flame tests, 11 of the 15 materials were selected for the brand test.

Results. There were three major events that we observed for a wide range of deck boards: accelerated (runaway) combustion, dripping or dropping of flaming combustibles, and collapse of deck boards. Since some of these events occurred long after the 3-min under-flame and secession of the brand exposures, the total test time was set at 40 min to ascertain that all events had been completed.

Table 2 gives observations over time for the under-flame test. The last five materials in the list had no negative events. Of the other ten materials, all but Trex would have failed mechanically (including unreinforced Bedford and Ecoboard). Two of the decking materials (Eon and Maxituf) had runaway combustion within the 3-min flame exposure and were extinguished at that time (but

would have also collapsed). Evernew (the only one made of polyvinyl chloride) did not burn, but vaporized in the area of the burner. Both of the deckboard materials with a “channeled” form on the underside (ChoiceDek and TimberTech) had early degradation effects, presumably from the increased surface area on the underside. The dripping of flammable material to the burner or the floor was prevalent with most of the materials as a consequence of the plastic formulations.

In Table 3, results for the “A” brand test are presented. As anticipated, this type of exposure delayed the dripping and collapse shown in Table 2. Also, only one material had accelerated combustion (Ecoboard) and its performance was similar to the under-flame test. Three materials performed without negative events in both exposures (solid Weatherbest, Redwood, reinforced Bedford) and two had similar performances (Ecoboard, Nexwood). The remaining 10 had differing events between the tests.

The material with the highest wood fraction (SmartDeck) appeared to lack the ability to support its own weight in long-term exposure. All of the deckboard materials with a “channeled” form on the underside (Eon, ChoiceDek, and TimberTech) had early degradation effects in the under-deck fire tests, presumably from the increased surface area. In the burning brand tests, this early degradation was not seen. On the other hand, all of the “hollow” construction products, which generally performed well in the under-deck tests, exhibited board collapse within the 40-min test period in the burning brand tests. This was no doubt due to the reduced thickness of the upper surface, since burn-through occurred in the hollow core areas, where flaming was sustained until the board collapsed. Although the polyvinyl chloride sample, EverNew, collapsed very quickly in the under-deck fire test, it did not exhibit sustained combustion, as did most of the polyethylene-based products. Eon, which appeared to be ABS [poly(α -methyl styrene)], underwent very rapid and intense runaway combustion, as did the all-polyethylene Maxituf. Eon caused the release of corrosive gases which degraded all instrumentation in the fire lab.

Table 4 gives the Peak Heat Release Rate for the under-flame tests (because of the 12-mph airflow, HRR measurements cannot be made for the “A” brand tests). In Table 2, the notation of acceleration of heat release was from visual judgment, since HRR is determined post-test. However, it is important that a quantitative measure of HRR be used, since visual judgment can be very arbitrary. Therefore, a cut-off point must be chosen. In comparing Tables 2 and 4, it is apparent that the visually-observed accelerated combustion was noted for all runs from Ecoboard to Eon, and none from reinforced Bedford to Rhinodeck. Only Nexwood was in question since one of three tests had accelerated combustion. Therefore, the threshold for detection of accelerated combustion was established at 100 kW or 25 kW/ft² (2.3 kW/m²).

Comments. All tests were videotaped and most had still photos taken. The tapes were used to verify direct observations. The assemblies were tested by the end of June 2001 and therefore the composition of the synthetic materials reflected those manufactured by that date. Since the composition of most of the deckboards is proprietary, the results in Tables 2 and 3 apply to the analysis shown in Table 1, and not to the particular trade name. Thus the user cannot assume that a newly-purchased product would necessarily have the same performance as the one of the same name tested, unless the manufacturer provides assurance that the product formulation has not changed. Most materials had some combustion that was accelerated by the open front edge of the deck assembly during the under-flame test. In general, this had little effect on the results, but was helpful to understand the effect of under-deck flamespread to the edge of a deck. For the most part, the ends of the deckboards were shielded by joists, however, fire occasionally spread under or around the joists. In this case, negative effects that could affect the degradation criteria were discounted. On the other hand, ends of deck boards do exist, and the exposure of core material in some products could make them more vulnerable to degradation. The common 3/16 in. (5 mm) gap spacing is used to drain standing water from decks and also permit the joist-deck board

interface to properly ventilate. However, virtually all products developed their initial flaming state by burner flames that penetrated through the deckboards. This becomes a bootstrapping process where the facing edges are mutually heated to sustain combustion. The ratio of low- to high-density polyethylene did not appear to have an effect on fire performance. It was anticipated that high ratios would not have performed as well as low, but this was not observed.

Conditions of acceptance. Based on the tests, the acceptance criteria listed in Standard SFM-5 were considered appropriate for each of the two tests. Because of the substantial difference between the tests, both are necessary for acceptance in Very High Fire Hazard Zones.

References.

1. Babrauskas, V., *Burning Rates*, Section 2, Chapter 1 in SFPE Handbook of Fire Protection Engineering, 2nd edition, (P.J. DiNenno, editor-in-chief), Society of Fire Protection Engineers, Boston (1995), pp 2-1 to 2-15.
2. Lee, B. T., Heat Release Rate Characteristics of Some Combustible Fuel Sources in Nuclear Power Plants, NBSIR 85-3195, National Bureau of Standards, Washington (1985).

Table 1. Deckboard Materials & Properties

Product	Form	Plastic Type	Density	Composition (%)		LDPE***	(%)
				Wood Fiber*	Plastic**	Ash	
Wood - Plastic Composites*							
ChoiceDek	channeled	polyethylene	0.91	48	50	2	44
Nexwood	hollow	polyethylene	1.17	46	42	12	11
Rhino Deck	solid	polyethylene	1.13	64	35	1	1
SmartDeck	solid	polyethylene	0.10	65	33	2	23
TimberTech	channeled	polyethylene	1.22	48	37	15	7
Trex	solid	polyethylene	0.92	53	46	1	38
WeatherBest	hollow	polyethylene	0.20	60	33	7	20
WeatherBest	solid	polyethylene	1.20	61	31	8	0
Plastic (pure or fiberglass reinforced)							
Bedford (reinforced)		solid polyethylene	1.06	0	85	15	12
Bedford (unreinforced)		solid polyethylene	0.97	0	97	3	0
Ecoboard	solid	polyethylene	0.85	0	99	1	10
Eon	channeled	ABS?	0.80	0	100	0	-
EverNew	hollow	polyvinyl chloride	1.44	0	90	10	-
Maxituf	solid	polyethylene	0.94	0	100	0	0
Wood							
Redwood	solid	--	0.40	100	0	0	-

* Percent of sample dissolved in acid digestion, corrected for acid-soluble ash. Pure or fiberglass-reinforced plastics not subjected to acid digestion procedure.

** For wood-plastic composites, "plastic" is the fraction insoluble in acid digestion, corrected for acid-insoluble ash.

*** For polyethylene-based products, %LDPE = LDPE/(LDPE + HDPE)*100. By pyrolysis-GC.

Table 2. Under-flame test, 3 min at 80 kW

Time (min)	0	5	10	15	20	25	30	35
40								
Eon		DA						
Maxituf	DA							
Evernew	M							
TimberTech	D	A M						
ChoiceDek		D	A	M				
Nexwood				D M				
Bedford (unreinforced)	D			A				
Ecoboard		D					A	
Trex							D	
Rhino Deck					M			
NO DEGRADATION EFFECTS								
Smart Deck								
Weatherbest (solid)								
Weatherbest (hollow)								
Bedford (reinforced)								
Redwood								
D = dripping flammable material A = accelerated (runaway) combustion M = mechanical collapse or one or more boards								

Table 3. Burning brand test (“A” brand)

Time (min)	0	5	10	15	20	25	30	35	40
Rhino Deck				D					
Ecoboard			D			A			
Nexwood				D		M			
Trex					D			M	
Smart Deck						D		M	
Weatherbest (hollow)									M
Bedford (unreinforced)		D							
NO DEGRADATION EFFECTS									
Bedford (reinforced)									
Weatherbest (solid)									
Redwood									
TimberTech									

D = dripping flammable material

A = accelerated (runaway) combustion

M = mechanical collapse or one or more boards

Table 4. Peak Heat Release Rate for deck assemblies exposed to 80 kW under-flame test. Average values for three tests unless otherwise noted.

Deck Material		HRR (kW)
Bedford (reinforced)		<10
Weatherbest (hollow)		<10*
Weatherbest (solid)		<10
Redwood		12
SmartDeck		15
Trex		29
RhinoDeck		90
Nexwood		165*
Ecoboard		203***
ChoiceDek		45***
TimberTech		394***
Bedford (unreinforced)	416***	
Maxituf		695** (only 2 runs)
Eon		1055* (only 1 run)

 * Number of tests with accelerated heat release (runaway).

4.3. Appendix III -Cost Estimates by Assembly Type

Table I: Wall Coverings & Claddings

A: Gypsum Sheathing/ Underlayment

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
1.0	<u>Estimate #1</u> 1/2" Gypsum, Type X and 1/2" T-1-11fir wood siding					
1.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
1.2	15# building paper	1	SF	0.03	0.10	0.13
1.3	1/2" T-1-11 wood siding	1	SF	1.25	1.08	2.33
1.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			1.87	2.00	3.87
2.0	<u>Estimate #2</u> 1/2" Gypsum, Type X and 5/8" T-1-11fir wood siding					
2.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
2.2	15# building paper	1	SF	0.03	0.10	0.13
2.3	5/8" T-1-11 wood siding	1	SF	1.35	1.12	2.47
2.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			1.97	2.04	4.01
3.0	<u>Estimate #3</u> 1/2" Gypsum, Type X and shiplap redwood siding					
3.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
3.2	15# building paper	1	SF	0.03	0.10	0.13
3.3	1/2" shiplap wood siding	1	SF	2.98	1.52	4.50
3.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.60	2.44	6.04
4.0	<u>Estimate #4</u> 1/2" Gypsum, Type X and bevel cedar wood siding					
4.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
4.2	15# building paper	1	SF	0.03	0.10	0.13
4.3	1/2" bevel wood siding	1	SF	3.45	1.38	4.83
4.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			4.07	2.30	6.37
5.0	<u>Estimate #5</u> 1/2" Gypsum, Type X and 1" 3 coat stucco with color					
5.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
5.2	15# building paper	1	SF	0.03	0.10	0.13
5.3	1" stucco, float finish, mesh, with color	1	SF	0.74	5.00	5.74
	TOTAL COST			1.02	5.54	6.56
6.0	<u>Estimate #6</u>					

	1/2" Gypsum, Type X and 7/16" hardboard siding					
6.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
6.2	15# building paper	1	SF	0.03	0.10	0.13
6.3	7/16" hardboard lap siding, primed	1	SF	1.46	1.20	2.66
6.4	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
	TOTAL COST			1.97	2.01	3.98
7.0	<u>Estimate #7</u>					
	1/2" Gypsum, Type X and vinyl siding					
7.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
7.2	15# building paper	1	SF	0.03	0.10	0.13
7.3	Vinyl siding	1	SF	0.97	1.49	2.46
	TOTAL COST			1.25	2.03	3.28
8.0	<u>Estimate #8</u>					
	1/2" Gypsum, Type X and 5/16" fiber cement siding					
8.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
8.2	15# building paper	1	SF	0.03	0.10	0.13
8.3	5/16" fiber cement siding	1	SF	1.18	1.73	2.91
8.4	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
	TOTAL COST			1.69	2.54	4.23
9.0	<u>Estimate #9</u>					
	1/2" Gypsum, Type X and 1" x 12" board and batten siding					
9.1	1/2" Gypsum, Type X	1	SF	0.25	0.44	0.69
9.2	15# building paper	1	SF	0.03	0.10	0.13
9.3	1" x 12" board & batten siding	1	SF	2.84	1.46	4.30
9.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.46	2.28	5.84

B. Plywood Sheathing/Underlayment

10.0	<u>Estimate #10</u>					
	3/8" plywood CDX and 1/2" T-1-11 fir wood siding					
10.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
10.2	15# building paper	1	SF	0.03	0.10	0.13
10.3	1/2" T-1-11 wood siding	1	SF	1.25	1.08	2.33
10.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			2.30	2.30	4.60

11.0	<u>Estimate #11</u>					
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3/8" plywood CDX and 5/8" T-1-11 fir wood siding						
11.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
11.2	15# building paper	1	SF	0.03	0.10	0.13
11.3	5/8" T-1-11 wood siding	1	SF	1.35	1.12	2.47
11.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
TOTAL COST				2.40	2.34	4.74
12.0	<u>Estimate #12</u> 3/8" plywood CDX and shiplap redwood siding					
12.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
12.2	15# building paper	1	SF	0.03	0.10	0.13
12.3	1/2" shiplap wood siding	1	SF	2.98	1.52	4.50
12.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
TOTAL COST				4.03	2.74	6.77
13.0	<u>Estimate #13</u> 3/8" plywood CDX and bevel cedar wood siding					
13.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
13.2	15# building paper	1	SF	0.03	0.10	0.13
13.3	1/2" bevel wood siding	1	SF	3.45	1.38	4.83
13.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
TOTAL COST				4.50	2.60	7.10
14.0	<u>Estimate #14</u> 3/8" plywood CDX and 1" 3 coat stucco with color					
14.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
14.2	15# building paper	1	SF	0.03	0.10	0.13
14.3	1" stucco, float, fin., mesh w/color	1	SF	0.74	5.00	5.74
TOTAL COST				1.45	5.84	7.29
15.0	<u>Estimate #15</u> 3/8" plywood CDX 7/16" and hard board					
15.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
15.2	15# building paper	1	SF	0.03	0.10	0.13
15.3	7/16" hard board siding lap siding, primed	1	SF	1.46	1.20	2.66
15.4	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
TOTAL COST				2.40	2.31	4.71
16.0	<u>Estimate #16</u> 3/8" plywood CDX and vinyl siding					
16.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
16.2	15# building paper	1	SF	0.03	0.10	0.13
16.3	Vinyl siding	1	SF	0.97	1.49	2.46
TOTAL COST				1.68	2.33	4.01
17.0	<u>Estimate #17</u> 3/8" plywood CDX and 5/16" fiber					

cement siding						
17.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
17.2	15# building paper	1	SF	0.03	0.10	0.13
17.3	5/16" fiber cement siding	1	SF	1.18	1.73	2.91
17.4	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
TOTAL COST				2.12	2.84	4.96
18.0	Estimate #18					
3/8" plywood CDX and 1" x 12"						
board and batten siding						
18.1	3/8" plywood CDX	1	SF	0.68	0.74	1.42
18.2	15# building paper	1	SF	0.03	0.10	0.13
18.3	1" x 12" board & batten siding	1	SF	2.84	1.46	4.30
18.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
TOTAL COST				3.89	2.68	6.57

C: Oriented Strand Board Sheathing/Underlayment

19.0	<u>Estimate #19</u>					
	3/8" oriented strand board and 1/2" T-1-11 fir wood siding					
19.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
19.2	15# building paper	1	SF	0.03	0.10	0.13
19.3	1/2" T-1-11 wood siding	1	SF	1.25	1.08	2.33
19.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			2.20	2.29	4.49
20.0	<u>Estimate #20</u>					
	3/8" oriented strand board and 5/8" T-1-11 fir wood siding					
20.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
20.2	15# building paper	1	SF	0.03	0.10	0.13
20.3	5/8" T-1-11 wood siding	1	SF	1.35	1.12	2.47
20.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			2.30	2.33	4.63
21.0	<u>Estimate #21</u>					
	3/8" oriented strand board and shi lap redwood siding					
21.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
21.2	15# building paper	1	SF	0.03	0.10	0.13
21.3	1/2" shi lap wood siding	1	SF	2.98	1.52	4.50
21.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.93	2.73	6.66

22.0	<u>Estimate #22</u>					
	3/8" oriented strand board and					

	bevel cedar wood siding					
22.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
22.2	15# building paper	1	SF	0.03	0.10	0.13
22.3	1/2" bevel wood siding	1	SF	3.45	1.38	4.83
22.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			4.40	2.59	6.99
23.0	<u>Estimate #23</u>					
	3/8" oriented strand board and 1" 3 coat stucco with color					
23.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
23.2	15# building paper	1	SF	0.03	0.10	0.13
23.3	1" stucco, float fin., mesh, w/color	1	SF	0.74	5.00	5.74
	TOTAL COST			1.35	5.83	7.18
24.0	<u>Estimate #24</u>					
	3/8" oriented strand board and 7/16" hard board siding					
24.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
24.2	15# building paper	1	SF	0.03	0.10	0.13
24.3	7/16" hard board lap siding, primed	1	SF	1.46	1.20	2.66
24.4	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
	TOTAL COST			2.30	2.30	4.60
25.0	<u>Estimate #25</u>					
	3/8" oriented strand board and vinyl siding					
25.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
25.2	15# building paper	1	SF	0.03	0.10	0.13
25.3	Vinyl siding	1	SF	0.97	1.99	2.96
	TOTAL COST			1.58	2.82	4.40
26.0	<u>Estimate #26</u>					
	3/8" oriented strand board and 5/16" fiber cement siding					
26.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
26.2	15# building paper	1	SF	0.03	0.10	0.13
26.3	5/16" fiber cement siding	1	SF	1.18	1.73	2.91
26.4	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
	TOTAL COST			2.02	2.83	4.85
27.0	<u>Estimate #27</u>					
	3/8" oriented strand board and 1" x 12" board & batten siding					
27.1	3/8" oriented strand board	1	SF	0.58	0.73	1.31
27.2	15# building paper	1	SF	0.03	0.10	0.13
27.3	1" x 12" board & batten siding	1	SF	2.84	1.46	4.30
27.4	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.79	2.67	6.46

D. Building Paper Underlayment

28.0	<u>Estimate #28</u>					
	Building paper and 1/2" T-1-11					

	fir wood siding					
28.1	15# building paper	1	SF	0.03	0.10	0.13
28.2	1/2" T-1-11 wood siding	1	SF	1.25	1.08	2.33
28.3	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			1.62	1.56	3.18
29.0	<u>Estimate #29</u>					
	Building paper and 1/2" T-1-11 fir wood siding					
29.1	15# building paper	1	SF	0.03	0.10	0.13
29.2	5/8" T-1-11 wood siding	1	SF	1.35	1.12	2.47
29.3	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			1.72	1.60	3.32
30.0	<u>Estimate #30</u>					
	Building paper and shiplap redwood siding					
30.1	15# building paper	1	SF	0.03	0.10	0.13
30.2	1/2" shiplap wood siding	1	SF	2.98	1.52	4.50
30.3	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.35	2.00	5.35
31.0	<u>Estimate #31</u>					
	Building paper and bevel cedar wood siding					
31.1	15# building paper	1	SF	0.03	0.10	0.13
31.2	1/2" bevel wood siding	1	SF	3.45	1.38	4.83
31.3	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.82	1.86	5.68
32.0	<u>Estimate #32</u>					
	Building paper and 1" 3 coat stucco with color					
32.1	15# building paper	1	SF	0.03	0.10	0.13
32.2	1" stucco, float fin., mesh, w/color	1	SF	0.74	5.00	5.74
	TOTAL COST			0.77	5.10	5.87
33.0	<u>Estimate #33</u>					
	Building paper and 7/16" hard board lap siding					
33.1	15# building paper	1	SF	0.03	0.10	0.13
33.2	7/16" hard board lap siding, primed	1	SF	1.46	1.20	2.66
33.3	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
	TOTAL COST			1.72	1.57	3.29

34.0	<u>Estimate #34</u>					
	Building paper and vinyl siding					
34.1	15# building paper	1	SF	0.03	0.10	0.13

34.2	Vinyl siding	1	SF	0.97	1.49	2.46
	TOTAL COST			1.00	1.59	2.59
35.0	<u>Estimate #35</u> Building paper and 5/16" fiber cement siding					
35.1	15# building paper	1	SF	0.03	0.10	0.13
35.2	5/8" fiber cement siding	1	SF	1.18	1.73	2.91
35.3	Paint with 2 finish coats	1	SF	0.23	0.27	0.50
	TOTAL COST			1.44	2.10	3.54
36.0	<u>Estimate #36</u> Building paper and 1" x 12" board and batten siding					
36.1	15# building paper	1	SF	0.03	0.10	0.13
36.2	1" x 12" board & batten siding	1	SF	2.84	1.46	4.30
36.3	Paint, primer with 2 finish coats	1	SF	0.34	0.38	0.72
	TOTAL COST			3.21	1.94	5.15

Table II: Roofing

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
37.0	<u>Estimate #37</u> Class A composition asphalt fiberglass shingles 250#/SQ					
37.1	Install composition (fiberglass) shingles over fiberglass 30# felt underlayment, complete	1	SF	0.71	0.71	1.42
	TOTAL COST			0.71	0.71	1.42
38.0	<u>Estimate #38</u> Concrete tile					
38.1	Install concrete tile over fiberglass 30# felt underlayment, complete	1	SF	1.54	2.25	3.79
	TOTAL COST			1.54	2.25	3.79
39.0	<u>Estimate #39</u> Class A fire retardant wood shingles over 1/2" Gypsum, Type X					
39.1	Install 1/2" Gypsum, Type X	1	SF	0.25	1.13	1.38
39.2	Install Class A fire retardant wood shingles over fiberglass 30# felt underlayment, complete	1	SF	2.75	1.43	4.18
	TOTAL COST			3.00	2.56	5.56
48.0	<u>Estimate #48</u> Class C, composition asphalt fiber shingles, 240 #/Sq.					
48.1	Install composition fiberglass shingles over fiberglass 30# felt underlayment, complete	1	SF	0.54	0.60	1.14
	TOTAL COST					1.14
49.0	<u>Estimate #49</u> Built-up (flat) roofing, 4-ply asphalt flood coat with gravel					
49.1	Install built-up 4-ply glass fiber (Type IV) mopped w/edge flashing, complete	1	SF	1.22	1.15	2.37
	TOTAL COST					2.37

Table III: Exterior Deck Surfaces

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
40.0	<u>Estimate #40</u> Redwood deck					
40.1	2" x 6" clear heart redwood floor	1	SF	15.84	2.73	18.57
40.2	stain/seal, 2 coats	1	SF	0.13	0.24	0.37
	TOTAL COST			15.97	2.97	18.94
41.0	<u>Estimate #41</u> Plastic deck (Trex)					
41.1	Plastic floor (Trex)	1	SF	4.50	2.73	7.23
	TOTAL COST			4.50	2.73	7.23
42.0	<u>Estimate #42</u> Membrane walking deck, urethane over plywood					
42.1	5/8" plywood	1	SF	0.70	0.74	1.44
42.2	Rigid urethane coating, 2 coats	1	SF	0.27	0.28	0.55
42.3	Paint floor decking primer and 2 finish coats, 2 sides	1	SF	0.46	0.54	1.00
	TOTAL COST			1.43	1.56	2.99

Table IV: Window Installation

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
43.0	<u>Estimate #43</u> Double pane aluminum window, 3'W x 4'H					
43.1	Install double pane aluminum window, complete	1	EA	313.88	49.85	363.73
	TOTAL COST			313.88	49.85	363.73
44.0	<u>Estimate #44</u> Triple pane aluminum window, 3'W x 4'H					
44.1	Install triple pane aluminum window, complete	1	EA	756.70	68.80	825.45
	TOTAL COST			756.70	68.80	825.50
45.0	<u>Estimate #45</u> Single pane, tempered, aluminum window, 3'W x 4'H					
45.1	Install single pane, aluminum window, 3'W x 4'H, complete, tempered	1	EA	187.41	48.75	236.16
	TOTAL COST			187.41	48.75	236.16

52.0	<u>Estimate #52</u> Single pane wood window, 3'wx4'h					
52.1	Install single pane wood window	1	EA	805.10	48.75	853.85
	TOTAL COST					853.85
53.0	<u>Estimate #53</u> Double pane wood window , 3'wx4'h					
53.1	Install double pane wood window, complete	1	EA	552.08	49.85	601.93
	TOTAL COST					601.93
54.0	<u>Estimate #54</u> Triple pane wood window, 3'wx4'h					
54.1	Install triple pane wood window, complete (No production)	N/A	N/A	N/A	N/A	N/A
	TOTAL COST					0.00
55.0	<u>Estimate #55</u> Single pane vinyl window					
55.1	Install single pane vinyl window, complete (No production)	N/A	N/A	N/A	N/A	N/A
	TOTAL COST					0.00
56.0	<u>Estimate #56</u> Double pane vinyl window					
56.0	Install double pane vinyl window, complete	1	EA	247.10	49.85	296.95
	TOTAL COST					296.95
57.0	<u>Estimate #57</u> Triple pane vinyl window					
57.1	Install triple pane vinyl window, complete	1	EA	817.29	68.80	886.09
	TOTAL COST					886.09

Table V: Roof Eave Installation

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
46.0	<u>Estimate #46</u> Eave with open soffitt \$ per LF					
46.1	Install 2" x 6" eave cover between rafters	1	LF	0.63	2.10	2.73
46.2	Drill 2" dia. hole	2	EA	----	2.80	5.60
46.3	Install 2" dia. screen	2	EA	0.58	1.02	3.20
46.4	Paint, primer with 2 finish coats	5.2	SF	0.34	0.38	3.75
	TOTAL COST			3.56	11.72	15.28
47.0	<u>Estimate #47</u> Eave with enclosed soffitt \$ per LF					
47.1	Install 2" x 4" side supports at wall and fascia	2	LF	0.38	1.73	4.22
47.2	Install 3/8" plywood soffitt	2	SF	1.36	1.48	5.68
47.3	Install vent screen, 3"	1	LF	0.44	1.99	2.43
47.4	Drill 2" Ø hole	2	EA	----	2.80	5.60
47.5	Paint, primer with 2 finish coats	2	SF	0.34	0.38	1.44
	TOTAL COST			4.60	14.77	19.37
61.0	<u>Estimate #61</u> Eave with stucco enclosed soffitt \$/LF					
61.1	Install 2"x4" side supports at wall & fascia	2.5	LF	0.48	2.30	6.95
61.2	Install 3/8" plywood soffitt	2	SF	1.36	1.48	5.68
61.3	Drill 2" diameter hole	2	EA	---	2.80	5.60
61.4	Install vent screen, 3"	1	LF	0.44	1.99	2.43
61.5	Install 1" stucco, mesh, w/color	2	SF	0.80	5.50	12.60
	TOTAL COST PER LF					33.26

Table VI: Venting

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
50.0	<u>Estimate #50</u> Roof eyebrow vent - 4"x19" (.5 SF)					
50.1	Install eyebrow vent (.5 SF)	1	SF	49.40	20.30	69.70
	TOTAL COST					69.70
51.0	<u>Estimate #51</u> Roofing ridge vent - 8", continuous					
51.1	Install ridge vent - 8", continuous	1	LF	3.01	1.87	4.88
	TOTAL COST					4.88

Table VII: Gutters

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	MATERIAL	LABOR	TOTAL \$/SF
58.0	<u>Estimate #58</u> Gutters - vinyl, 5" wide					
58.1	Install 5" vinyl gutters	1	LF	1.41	3.45	4.86
	TOTAL COST					4.86
59.0	<u>Estimate #59</u> Gutters, aluminum, 5" wide					
59.1	Install 5" aluminum gutters	1	LF	1.28	3.83	5.11
	TOTAL COST					5.11
60.0	<u>Estimate #60</u> Gutters, 26 Ga., galvanized steel					
60.1	Install galvanized 26 Ga. steel gutters	1	LF	1.34	3.83	5.17
	TOTAL COST					5.17

4.4 Appendix IV- Vinyl Window Fire Performance



Rancho Santa Fe Fire Protection District
PO Box 410 / 16936 El Fuego
Rancho Santa Fe, CA 92067
(858) 756-5971

August 24, 2001



County of San Diego
Department of Planning and Land Use, Building Division
5201 Ruffin Road, Suite B, San Diego, CA 92123 (858) 565-5920

Advanced Window Technology
4966 Santa Monica Avenue, Suite A
San Diego, CA 92107

Dear Vinyl Window Retailer:

In May of this year we sent your company the enclosed letter stating that due to the wildland fire hazard and public safety concerns, vinyl window assemblies were not acceptable for use in homes within wildland/urban interface areas. Recently, the Forest Products Laboratory at U.C. Berkeley completed extensive testing of vinyl windows to determine their performance in the wildland/urban interface environment. Tests have concluded that vinyl window assemblies containing certain characteristics performed satisfactorily for use within these areas.

Based on this information, vinyl window assemblies are now acceptable for use within wildland/urban interface areas in the County of San Diego (unincorporated areas) and Rancho Santa Fe Fire Protection District, as long as the windows have the following characteristics:

1. Frame and sash are comprised of vinyl material with welded corners.
2. Metal reinforcement in the interlock area.
3. Frame and sash profiles are certified in AAMA Lineal Certification Program (Verified with either an AAMA product label or Certified Products Directory)
4. Certified and labeled to ANSI / AAMA / NWWDA 101/I.S.2-97 for Structural requirements.
5. Glazed with insulating glass, annealed or tempered.

Vinyl window assemblies that do not contain these characteristics are still not acceptable within local wildland/urban interface areas.

In order to verify each window meets the aforementioned five characteristics, vinyl window assemblies must be properly labeled. In addition, the specification sheets for these windows should be made available to window purchasers to show fire inspectors at final inspection; this will help us ensure the permissible windows have been installed.

Thank you for your time and consideration in regards to this safety matter.

Respectfully,

Erwin L. Willis, Fire Chief
Rancho Santa Fe Fire Department
(858) 756-5971

Clifford F. Hunter, Fire Code Specialist
Building Division, County of San Diego
Department of Planning and Land Use
(858) 694-2951

Enclosure

4.5 Appendix V-Typical Housing Parameters

Dimensions associated with typical 1750 square foot ranch home

Typical House Ranch Style, Single Story w/2 Car Garage	
Living Floor Space	1,750 SF
Roof	3,035 SF
Eave	226 LF
Exterior Wall (W/O glass)	2,548 SF
Exterior Wall Glass	204 SF